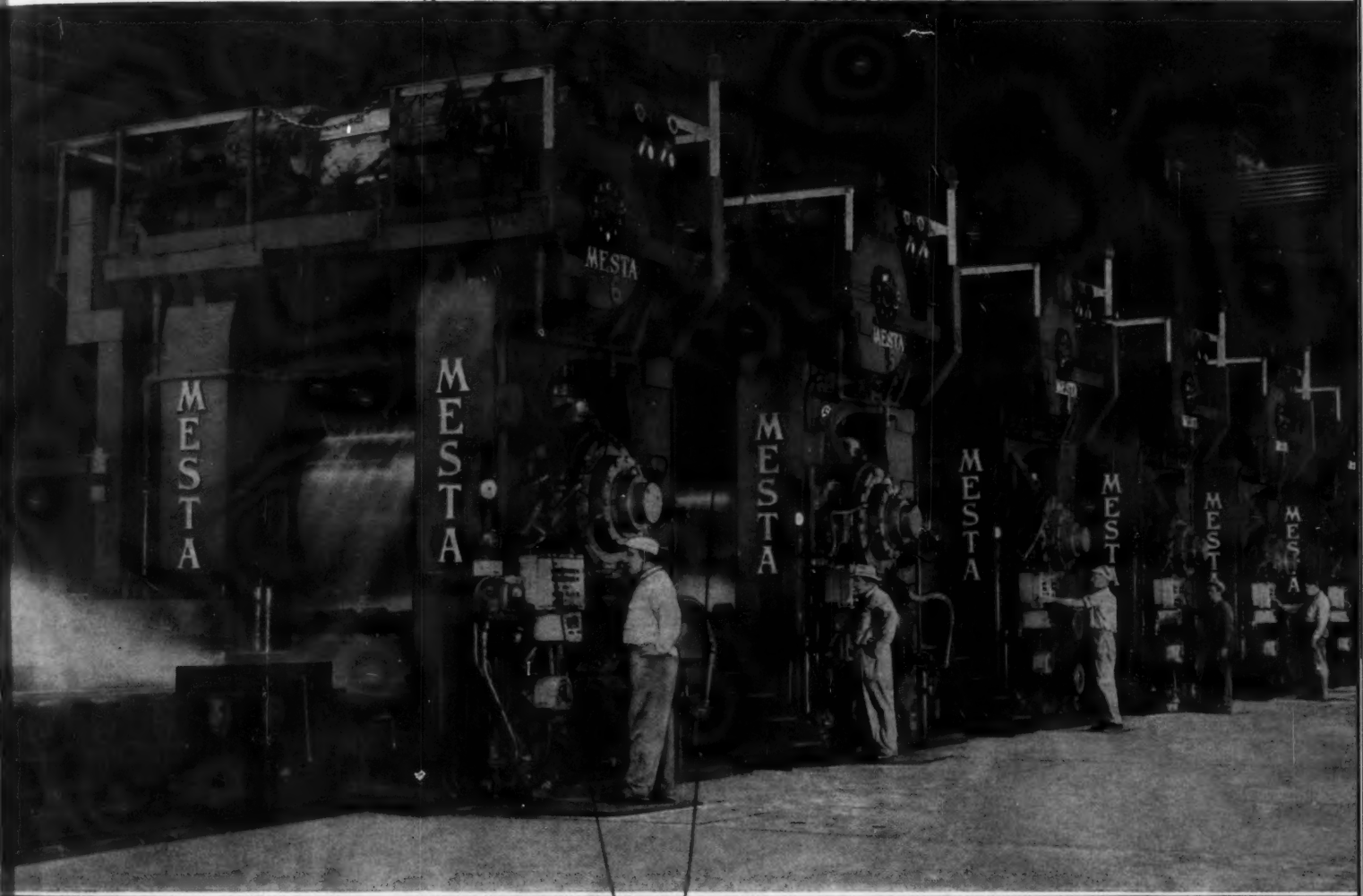
Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

APRIL, 1960

TECHNICAL DEPARTMENT



SIX FINISHING STANDS OF THE MESTA 60" FOUR-HIGH HOT STRIP MILL
OPERATING AT McLOUTH STEEL CORPORATION, TRENTON, MICHIGAN

HOT STRIP MILLS

Designed and Built by MESTA

Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA, U.S.A.

MESTA
THERE IS NONE BETTER

Look what's behind Cutler-Hammer's new trademark

You can see the new power at Cutler-Hammer wherever you look. New products. New engineering depth, particularly in industrial automation. New plants and streamlined marketing methods, too. Even a new trademark to reflect this new vitality.

If you're planning ahead for the great growth of the sixties, come to the company that's ready to plan ahead with you. Look at just a few of the new products that are already improving efficiency in many fields:

NEW *computer system for establishing quality of tinplate coils*

NEW *limit switch that outlasts others by at least two times*

NEW *automated system for charging blast furnaces in steel mills*

NEW *stacker that counts and stacks newspapers automatically*

NEW *Safetybreaker line of service entrance equipment*

WHAT'S NEW? ASK...

CUTLER-HAMMER

CONTROL

Cutler-Hammer Inc., Milwaukee, Wis. • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

Automatic Bull Block

for copper

Place coil in tray and feed point into die. Press the button, that's all. This Automatic Bull Block does the rest. Finished tubing emerges. Features include Automatic Gripping, Automatic Grip Release, Heavy Traverse Feed.

This is a 36" Bull Block drawing down copper from 5/8" to 1/8" at high speeds.

The Automatic Bull Block can be furnished in all sizes up to 84" diameter. Producing long lengths at high speeds automatically really brings down those costs. For complete information on the Block or any other Cold Draw equipment for tubes, bars, or shapes, write to: Cold Draw, Aetna-Standard Division, Blaw-Knox Company, Pittsburgh 30, Pennsylvania.

Aetna-Standard Division
BLAW-KNOX

J&L gets new production versatility with two rugged Wean Shearing Lines

Jones & Laughlin Steel Corporation's Cleveland Works Division has added these modern Wean shearing lines to satisfy an increasingly wide range of customer requirements. Both lines can handle 30,000# coils up to 75" wide. The Upcut Shear Line (left) can side-trim and shear strip up to ⅜" thick, with cut-lengths varying from 48" to 500", at a maximum speed of 140 fpm.

The combination Flying Shear Line (right) shears strip up to ¼" in thickness, with maximum cut lengths of 288", at speeds up to 350 fpm. This high-speed Wean line also permits combinations of side-trimming, slitting, temper passing and shearing or recoiling operations.

If you are planning expansion or modernization of your hot rolled strip shearing facilities, a Wean representative will welcome the opportunity to discuss your requirements. Wean's *creative engineering* can mean new profits for you.

WEAN

THE WEAN ENGINEERING COMPANY, INC. • WARREN, OHIO

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ARMCO uses North American
Refractory-Lined Dual-Fuel Burners

Four new Salem-Brosius slab heaters in Armco Steel Corporation's Middletown Works Hot Strip Mill are fired with North American Series 6819 Burners with internal mixing oil atomizers and Sensitrol Valves. Air is preheated to 700 F. Fuel is natural gas or #6 oil.

The top bank of each furnace has eight 10" burners and two 8" burners firing in the direction of work travel; bottom bank has five 10" burners and two 8" burners firing in the opposite direction. Each 10" burner releases 5,200,000 Btu/hr with 700 F air at 2" wc; each 8" burner releases 3,600,000 Btu/hr.

Furnaces are 27' wide x 34' long inside, and are designed for 125 tons of hot slabs per hour.

Here's Why You Should Too:

1. **Low maintenance**—quality alloy and refractory materials—metal parts not exposed to furnace radiation—designed for 1200 F preheated air.
2. **Easy accessibility**—quick disconnect atomizer—all parts removable from back.
3. **Retractable oil atomizer**—can be pulled back quickly and easily for gas firing.
4. **Gas and air openings proportional** for all sizes; so a variety of burner sizes can be used on the same manifold.
5. **Long or short flame** models available.
6. **Internal or external mixing atomizers** available.
7. **Low first cost**—plus North American's reputation for good service—in engineering and on the job site.

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

Call your nearby North American engineer or write for DF 6819

The North American Mfg. Co.
Cleveland 5, Ohio

New switch for matchless safety

Now, for the first time, the new American Electric Type "ND" Safety Switch offers *all* of the features "most wanted" in *one* safety switch by people who work with and use electrical equipment.

Included among the many "extras" to be found in this newest of safety switches are: visible double blade construction; positive, snap-action make and break; double insulation between blades and operating mechanism; optimum-size enclosures for maximum heat dissipation; plenty of wiring space for easier, faster installation; and an exclusive safety-yellow operating handle for quick, positive "spotting" even in poor light.

These and countless other field-tested design standouts assure the ultimate in safety switch protection with maximum operating life.

This new American Electric Normal Duty Safety Switch is, in fact, the result of the same kind of thorough engineering research and workmanship which has long made Clark Controller *"the standard of quality"* for industrial electrical control.

It meets NEMA standards for normal duty industrial and commercial use and is approved by Underwriters' Laboratories for these applications as well as for service entrance equipment. It is currently available in 30-ampere and 60-ampere, 250-volt and 600-volt ratings, both fusible and non-fusible.

Bulletin 250-ND fully describes every detail of this new switch designed for "matchless safety". For your free copy see your nearest American Electric Switch—Clark Controller Company distributor. Or, write direct. 9331

American
ELECTRIC SWITCH DIVISION

The **CLARK CONTROLLER** *Company*

Everything Under Control • 1146 East 152nd Street • Cleveland 10, Ohio

Another TAMUL balanced mixer lining goes into service

Major steel producers continue to prove TAMUL (Taylor mullite) the most economical refractory for lining hot metal mixers. Linings are "balanced" with TAMUL brick, laid in TASIL cement, in the areas of severe erosion.

Reduce patching and replacements to a minimum with TAMUL. A Taylor field engineer can give you full details on proven TAMUL applications for mixers, ladles and hot metal cars. He will welcome your inquiry.

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The **CHAS. TAYLOR SONS Co.**
A SUBSIDIARY OF NATIONAL LEAD COMPANY
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REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U. S. A.

Think what you can do with an open coil. Lee Wilson engineers, ever searching for better ways to anneal metal, scored an important breakthrough by devising a workable method for opening and handling large coils of steel. This has proved to be the most effective way to anneal yet discovered. But there's more—already several steel engineers have considered the open coil system the ideal station for oiling, cleaning, coating and other surface treatments in addition to annealing. Think what complete surface exposure means to your processing of sheet products, then contact Lee Wilson engineers for complete details and/or test coil arrangements.

Lee Wilson* ENGINEERING COMPANY, INC.

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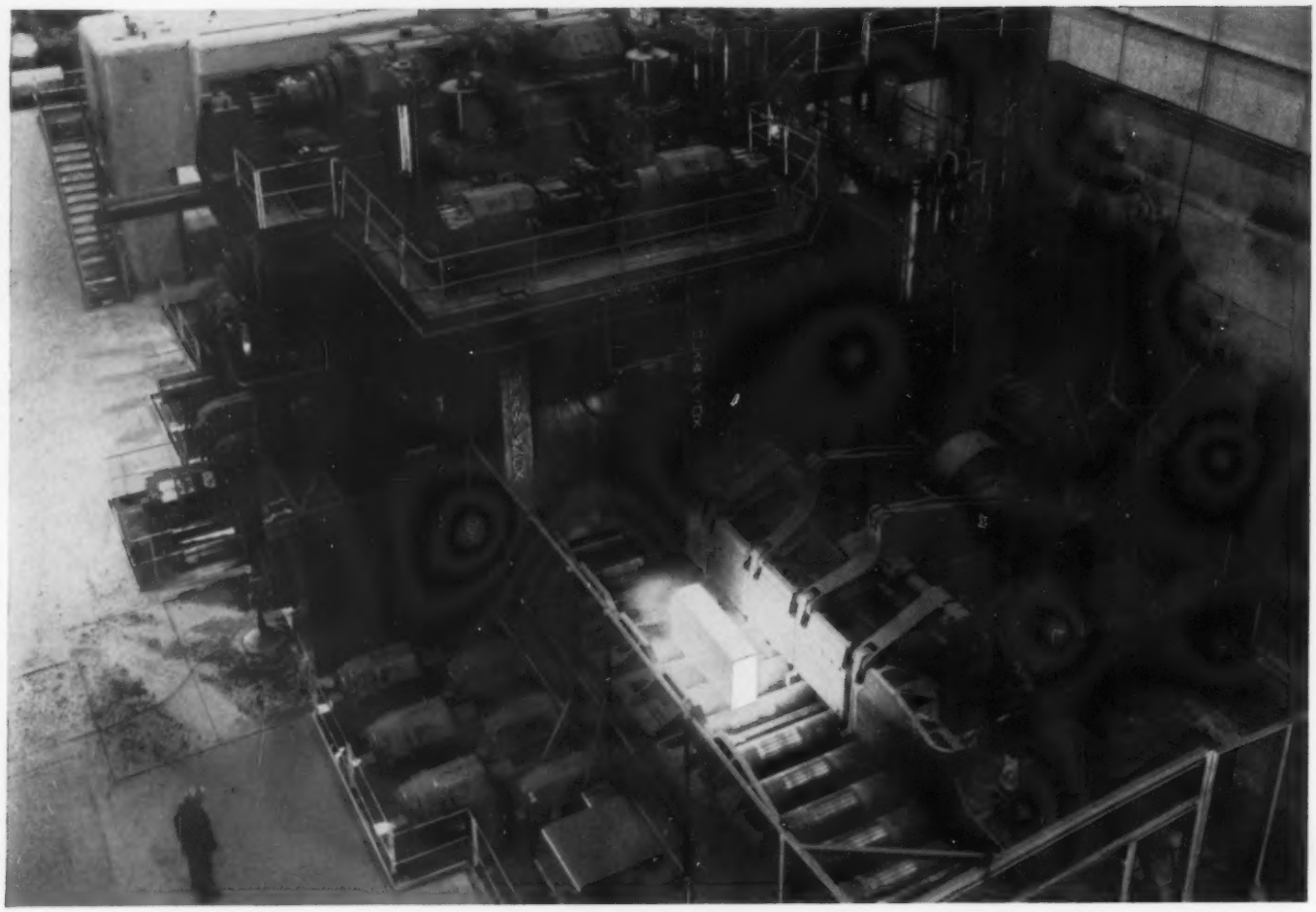
HIGH PRODUCTION ANNEALING SYSTEMS

MAKE THE BEST METALS BETTER

* ORIGINATORS AND LEADING PRODUCERS OF OPEN COIL AND SINGLE STACK FURNACES



Time, power, maintenance saved on Blaw-Knox two-high slabbing mill

BLAW-KNOX wanted to be sure this new 46″ x 90″ 2-high slabbing mill would work steadily, economically, under tremendous shock loads. They mounted roll necks, screwdowns, edger, edger drives, table drives and table line shaft on Timken® tapered roller bearings.

Result: *Less downtime* in roll changes; the Timken bearings and roll assembly can be removed easily as a unit; *low starting resistance* and less power required because Timken bearings practically eliminate friction; *reduced maintenance* on screwdown and breaker block, because Timken bearings hold the upper roll in place, eliminating the "jump" when slab or bloom enters the mill.

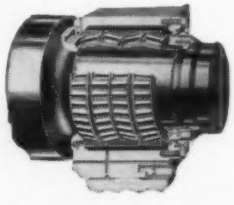
More than 1,000 mill installations the world over use Timken roll neck bearings, 1) *To roll the load*—virtually eliminate friction. Timken bearings have tapered design to take both radial and thrust loads. 2) *Minimize maintenance:* Modern Timken roll neck bearings are designed to provide the best combination of bearing capacity, rigidity and roll neck strength for a given mill roll diameter. Bearings and roll necks stand up longer under load. Grease or oil mist lubrication provides further economies. And, 3) *give longer bearing life.* Mill records show that service life of Timken back-up roll bearings has been obtained in excess of 12,000,000 tons of steel rolled. The full-line contact between rollers and races gives them extra load-carrying capacity.

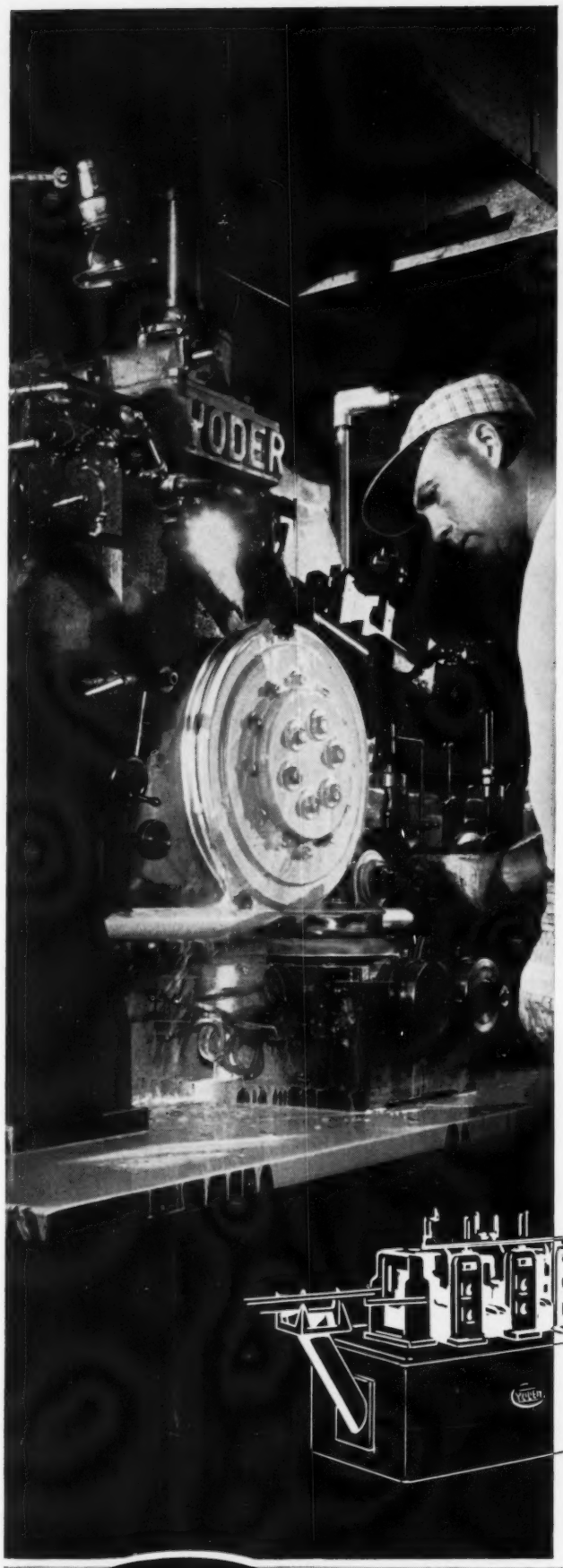
For the best bearing performance and engineering service when you build or buy a mill, specify Timken tapered roller bearings. They make any machine better. ***When you buy Timken bearings you get...*** *1) Quality you can take for granted. 2) Service you can't get anywhere else. 3) The best-known name in bearings. 4) The pace setter in lower bearing costs.* The Timken Roller Bearing Company, Canton 6, Ohio. *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.* Canadian plant: St. Thomas, Ontario, Cable address: "TIMROSCO".

BETTER-NESS rolls on

TIMKEN®

tapered roller bearings





Yoder Tube Mills speed tailpipe production at AP Parts Corporation

The AP Parts Corporation (Toledo, Ohio), world's largest producer of replacement mufflers and tailpipes, uses 2 YODER Tube Mills to produce more than *300* ft. of 1¾", 1⅞" and 2" tubing per minute.

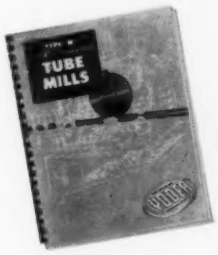
According to Mr. John Grindle, Plant Engineer, the two-man operated YODER Mills are vital to the production of the entire plant. "YODER Tube Mills earn their keep daily. They are easy to set up, maintain and operate . . . the welds are clean and uniform. We depend on them for constant quality, high production and minimum downtime".

The YODER Tube Mills at AP Parts exemplify the production economies and dependability of all YODER-built equipment, whether it be Pipe and Tube Mills, Cold Roll-Forming Machinery or Slitting Equipment.

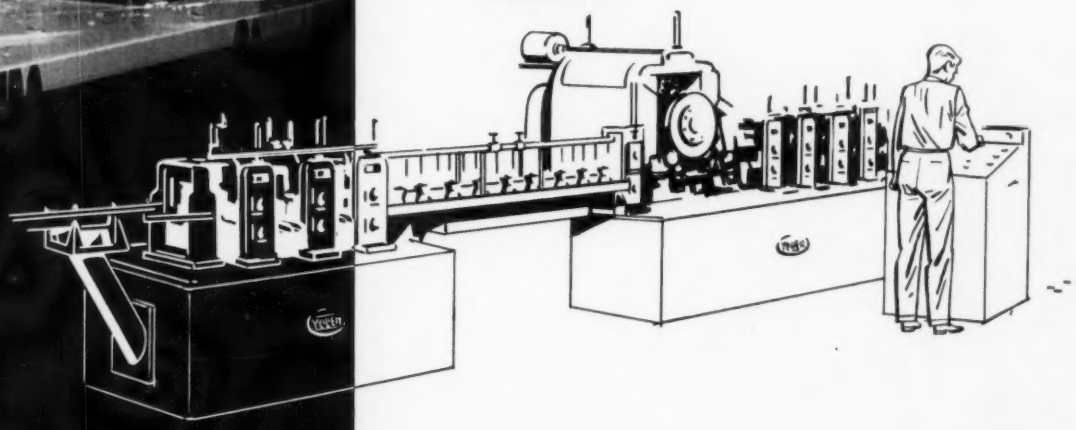
If your products require ferrous or non-ferrous pipe or tubing, from ¼" to 26" diameters, there is a YODER Mill designed to produce it economically, accurately and efficiently.

THE YODER COMPANY

5495 Walworth Avenue • • Cleveland 1, Ohio



For complete information on YODER Pipe or Tube Mills . . . write for the fully illustrated, 88 page YODER Tube Mill Book . . . it is yours for the asking.

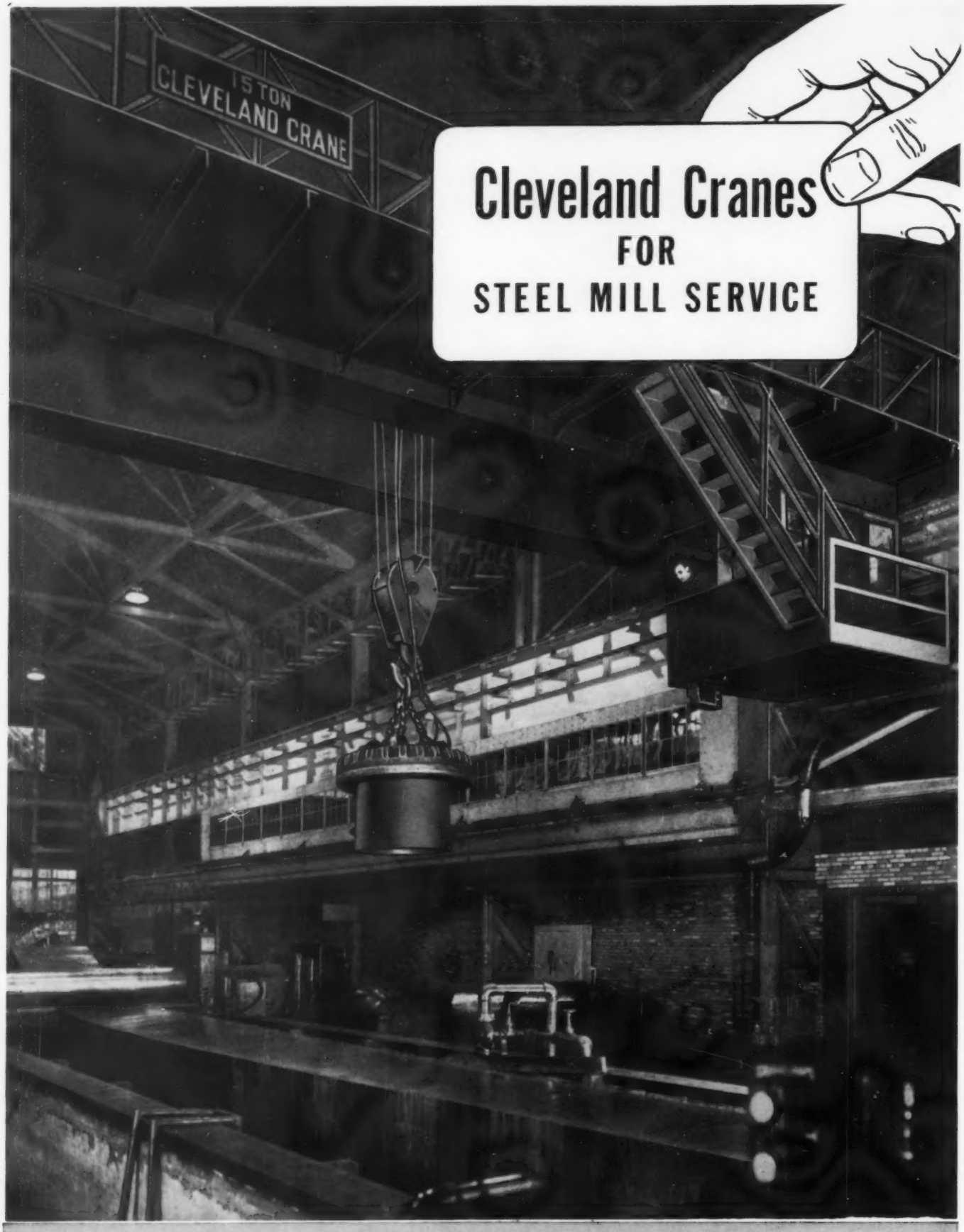


ENGINEERING YODER MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)

COLD ROLL FORMING MACHINES

ROTARY SLITTING LINES



Cleveland Cranes
FOR
STEEL MILL SERVICE

CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

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WICKLIFFE,
OHIO

Crops *and* Shorts

△ The 1960 AISE western meeting in San Francisco, March 7, 8, 9, was the usual success, with 520 registrants. Comments indicated the feeling that the technical program was better than usual. The trip to Mare Island Naval Shipyard was labeled a "welcome relief from the usual," and showed some of the landlocked steelmen some applications of their products.

We might report that California fell down on the usual fine weather they have furnished for previous meetings. Rain persisted for the first two days but fortunately cleared off for the final day.

△ The American Iron and Steel Institute has divided the industry into 11 new producing districts, as follows:

	Annual capacity, Net Tons
Pittsburgh	31,870,890
Chicago	29,567,900
Northeast Coast	20,724,880
Youngstown	15,384,200
Western	9,506,500
Southern	8,619,100
Cleveland	8,113,000
Detroit	7,984,000
Buffalo	7,652,710
Cincinnati	5,667,790
St. Louis	3,480,000
Total	148,570,970

This includes 149 plants of 84 companies.

△ Truly, it has been a time of paytriotism. Now that the April 15 moans are subsiding:

Another thing I'll never learn,
Although it's plain to some, no doubt,
Is why they call it a "return"
When all I do is shell it out.

△ Bethlehem Steel Co. recently announced plans to boost annual capacity of its Sparrows Point Plant to 9,000,000 ingot tons. Bethlehem apparently wants to hang on to the "world's largest" tag.

△ The past winter reminds us that we ought to do something about these crackpots who long for the good old-fashioned winters. And now that it's over, don't forget to get out that rake, lawn roller, mower and other fiendish equipment of the season.

△ Armco's No. 3 blast furnace at Middletown, U. S. record holder, broke its own record in February with an average daily production of 2696 net tons of iron. Its previous record, established in May, 1959, was 2690 tons per day.

△ Floor covering manufacturers have headaches caused by the spike heels currently in vogue for women's shoes, which make indentations in some tiling and snags in carpeting. They estimate a 112-lb lass on spike heels exerts 4000 lb pressure per sq in., while a 220-lb man in regular shoes sets up only 24 lb per sq in.

△ Foreign sources now supply more than one-third of the iron ore used in the United States, principally because it is some 10 to 20 per cent cheaper to mine and transport ore from abroad. Venezuela is the largest supplier, with Canada close behind; Chile, Peru, Brazil and Liberia also contribute. Total imports for 1959 were 39,900,000 net tons.

△ Motor vehicles registered in the United States in 1959 totaled 70,416,000. Total registrations in the world in 1958 were 111,912,841.

△ A new world's safety record of 10,214,912 man-hours worked without a disabling injury was set up by U. S. Steel's Gary Works. The previous record of 10,158,398 man-hours was held by the Lorain plant of National Tube Division of U. S. Steel.

△ Someone tells us that, when you're average, you are the best of the lousiest and the lousiest of the best.

△ Employment costs per hour for hourly employees in the iron and steel industry for 1959 reached a new high of $3.798. For the month of January, 1960, this figure reached $3.849. These figures include benefit costs of 38.1 cents per hour for 1959 and 45 cents per hour for January, 1960.

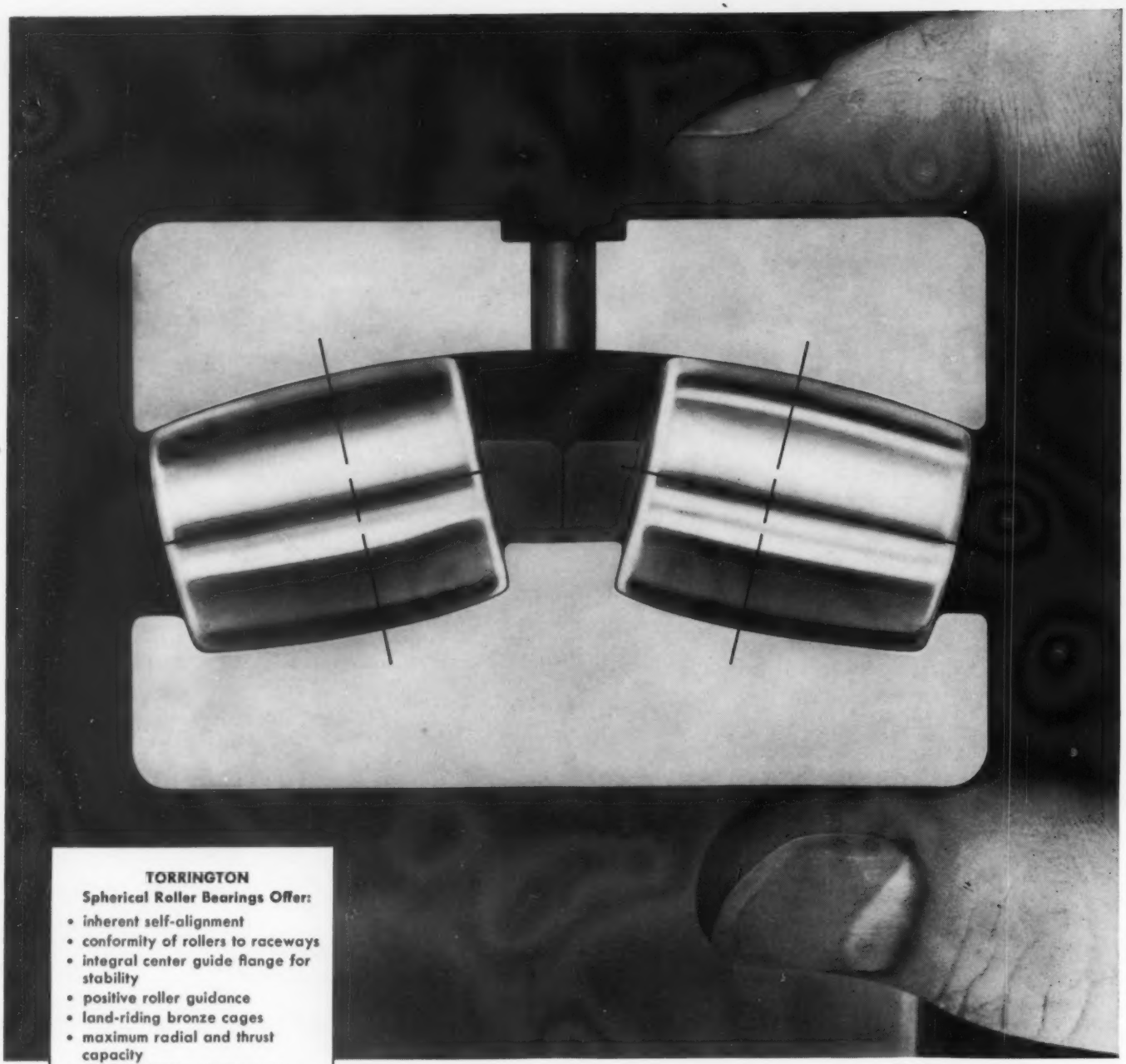
△ Clothes may not make the man but they can sure break husbands.

△ The 1960 Iron and Steel Exposition, to be held in Cleveland, Ohio, September 27, 28, 29, 30 in conjunction with the AISE annual convention, will be larger than any of its predecessors. The demand for exhibit space has already necessitated the layout of additional booths and these are going rapidly.

It looks like a real good affair. Make your plans to attend.

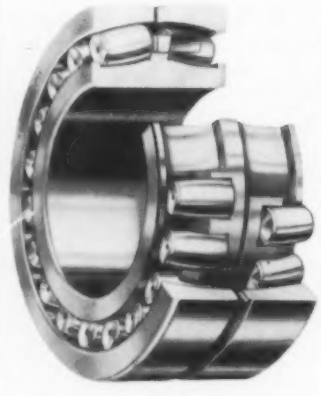
△ When heavy snow and rain bogged down a Michigan contractor's earth-moving equipment, he used an ox team to clean out drainage ditches. Ah, progress—she's wonderful!

△ Employment of hourly and salaried workers in the steel industry increased to 642,506 during February, the highest total in three years. Hourly employees averaged $3.372 per hour, plus about 45 cents in benefits, and worked 40.0 hours per week.



TORRINGTON
Spherical Roller Bearings Offer:

- inherent self-alignment
- conformity of rollers to raceways
- integral center guide flange for stability
- positive roller guidance
- land-riding bronze cages
- maximum radial and thrust capacity
- controlled internal clearance
- electronically selected rollers
- even load distribution
- long, dependable service life



Shaped for Stability!

The asymmetrical shape of each roller in Torrington Spherical Roller Bearings contributes directly to operating stability and long service life.

The maximum roller diameter is not at the center of the roller. Located towards the center flange, it insures geometric positioning of the roller for positive guidance with free rolling action.

The roller shape also approaches that of a tapered roller. Lines extended from the roller-to-race contact zone converge at the roller and bearing axes. This approach to true conical rolling action further assures stability.

These are two more reasons why Torrington Spherical Roller Bearings operate cooler, quieter and with greater stability. For the ultimate in bearing performance and service life, always specify *Torrington* Spherical Roller Bearings. Send for new Torrington Spherical Roller Bearing Catalog #258.

progress through precision **TORRINGTON BEARINGS**

THE TORRINGTON COMPANY South Bend 21, Indiana • Torrington, Conn.

Field rings were breaking brushes!

NATIONAL TRADE-MARK **stopped brush breakage!**

DOWN-TIME COULD HAVE COST THIS POWER COMPANY A FORTUNE!

"RED" BLACKBURN

PROBLEM: Threading and grooving of the steel field rings on giant turbine generators.

RECOMMENDATION: "National" brush grade 634.

RESULTS: This brush eliminated threading, grooving and resisted breakage and chipping when applied to eccentric rings.

Contact your "National" Brush Man

UNION CARBIDE

"National", "N" and Shield Device, and "Union Carbide" are registered trade-marks of Union Carbide Corporation

NATIONAL CARBON COMPANY • **Division of Union Carbide Corporation** • ***30 East 42nd Street, New York 17, N.Y.***

OFFICES: Birmingham, Chicago, Houston, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco • **CANADA:** Union Carbide Canada Limited, Toronto

This is the largest installation of soaking pits ever built at one time. It will heat an average of 750 tons of ingots per hour. At peak capacity, it will fill the ingot buggies at a rate of 1200 tons per hour.

Worldwide engineering and manufacturing facilities through associates in Australia • Belgium • France • Germany • Great Britain • Italy • Japan

■ Forty-eight soaking pits on *one order*. There's a bold act of customer confidence for you! Confidence in the future, for one thing. Confidence in the principle of the Surface one-way fired soaking pit with the jet pump recuperator system. Many other steelmakers have shown similar faith in Surface—a source of pride, matched by our determination to deserve it, ***wherever heat is used in industry***

48 PITS

SURFACE COMBUSTION

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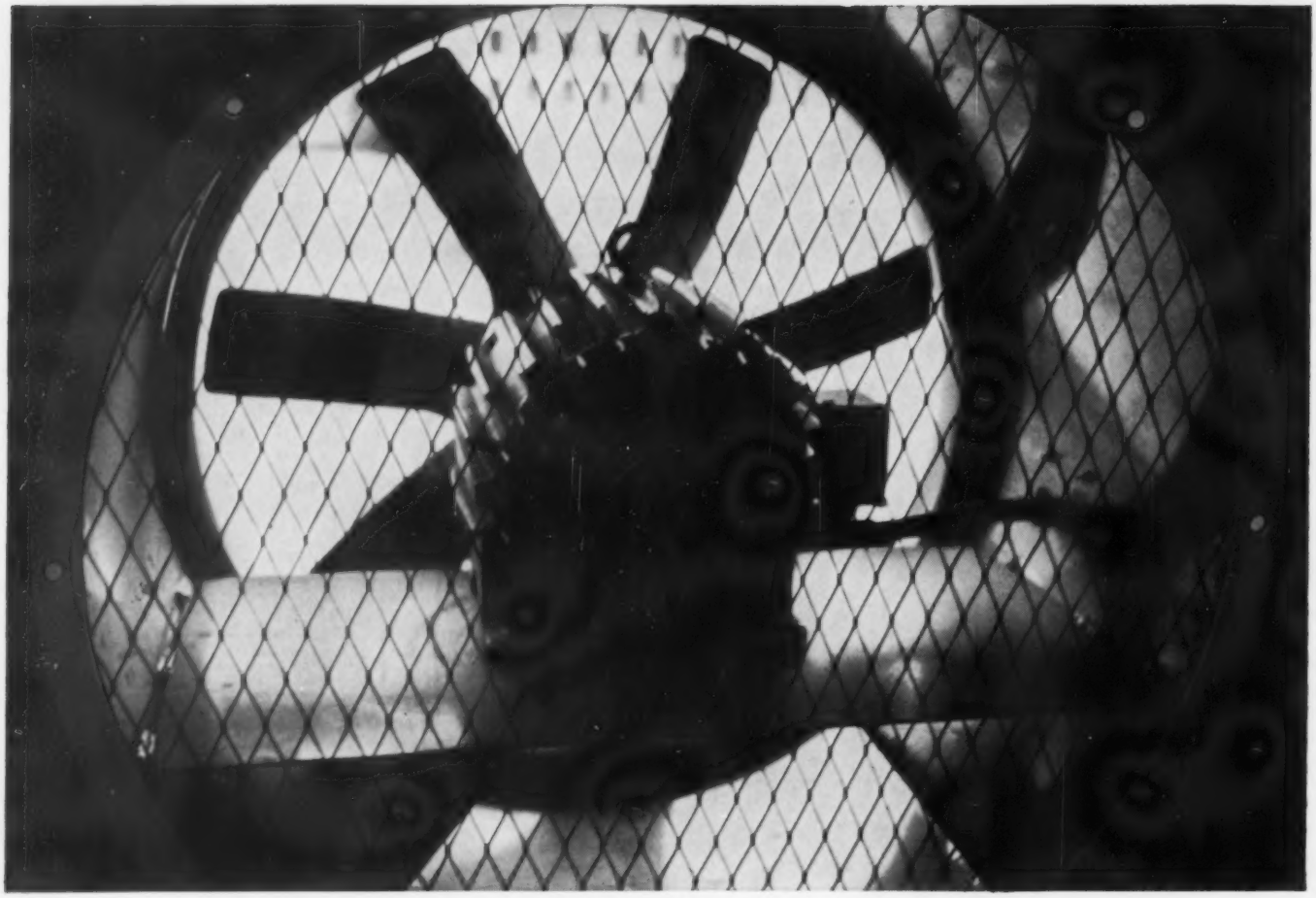
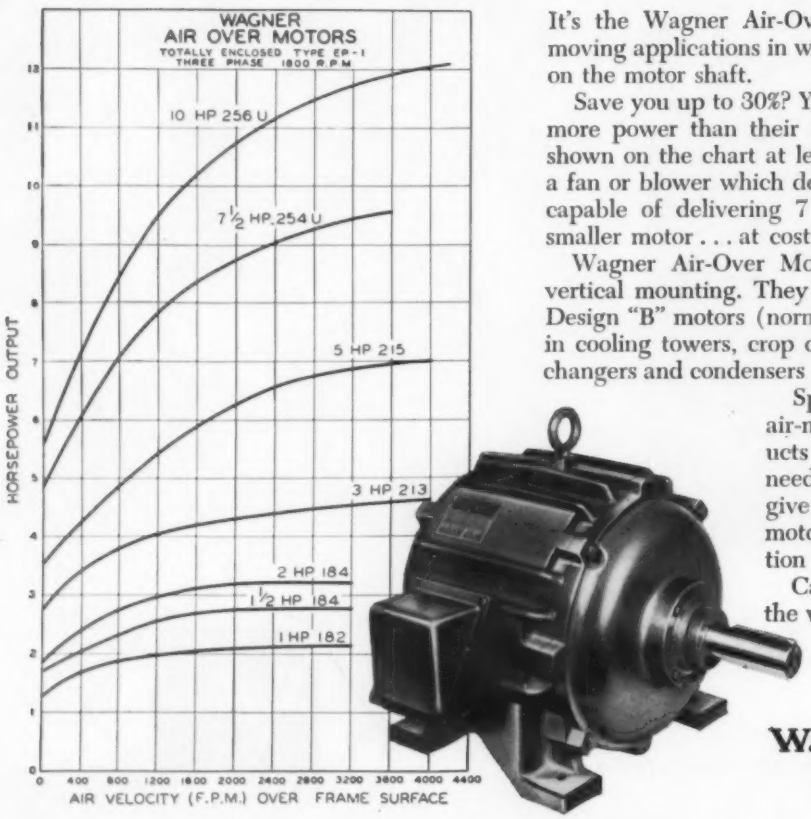
A Division of Midland-Ross Corporation

Surface



This Wagner Motor can save you up to 30% in costs on air-moving equipment



It's the Wagner Air-Over Motor . . . *specifically* designed for air-moving applications in which a propeller or axial flow fan is mounted on the motor shaft.

Save you up to 30%? Yes, for Wagner Air-Over Motors can deliver more power than their rated horsepower output. For example, as shown on the chart at left, a 5 horsepower rated motor installed in a fan or blower which delivers about 4,000 feet of air per minute is capable of delivering 7 horsepower. You get more work from a smaller motor . . . at costs up to 30% less.

Wagner Air-Over Motors are suitable for either horizontal or vertical mounting. They are totally-enclosed, nonventilated NEMA Design "B" motors (normal torque—normal slip). You can use them in cooling towers, crop dryers, exhaust systems, air-cooled heat exchangers and condensers . . . any air-over fan and blower application.

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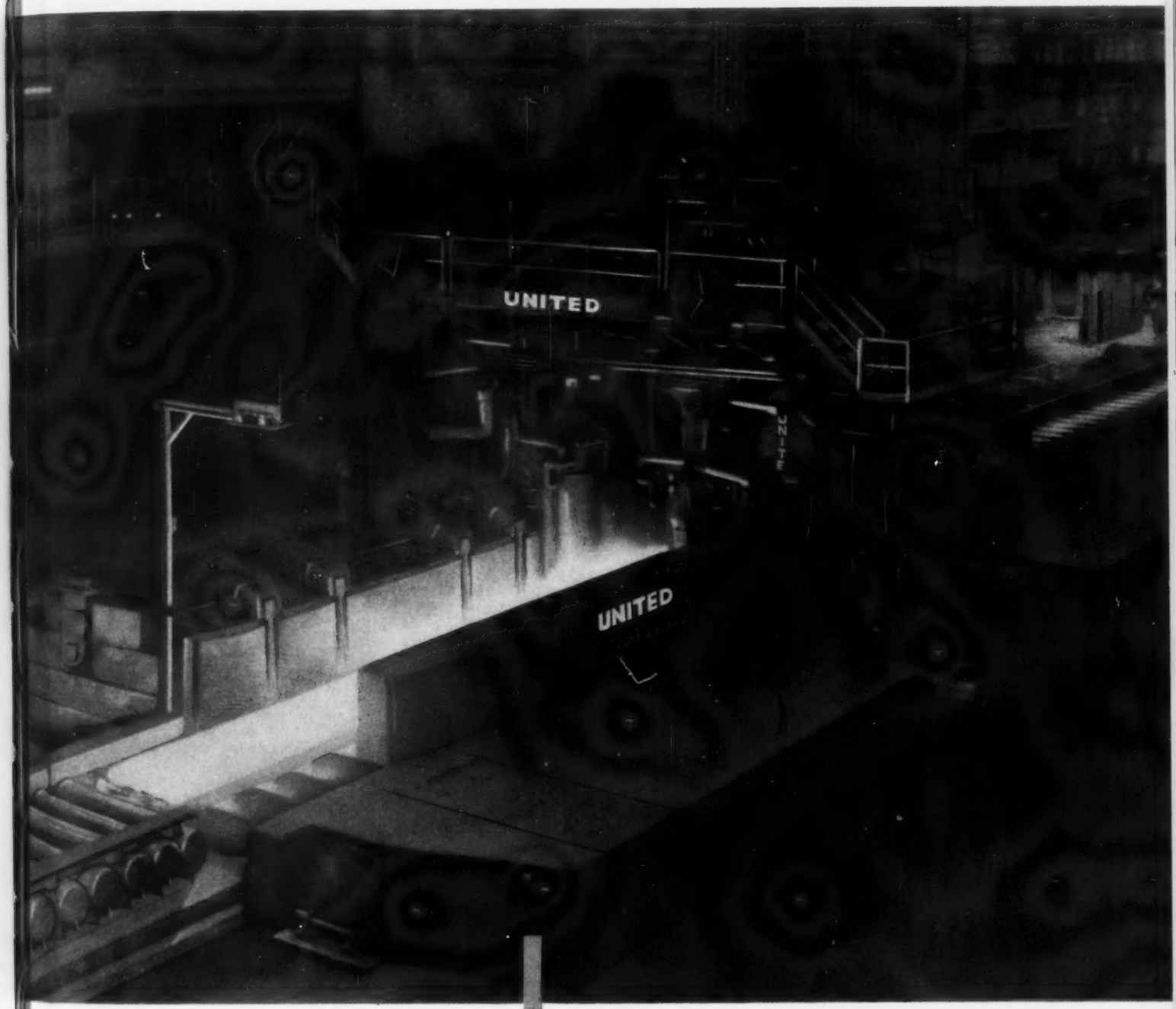

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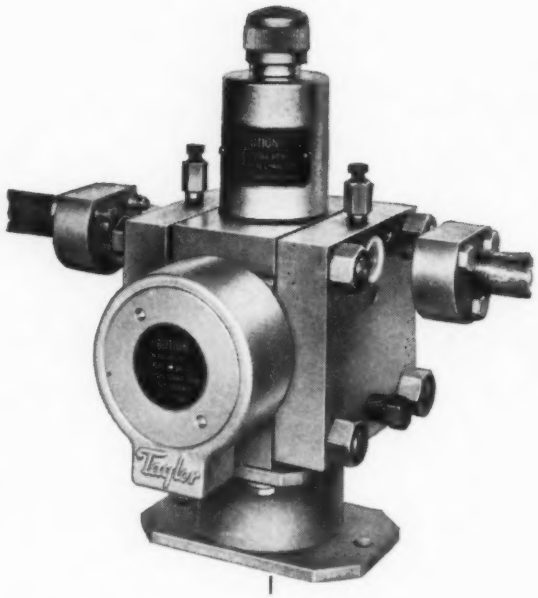

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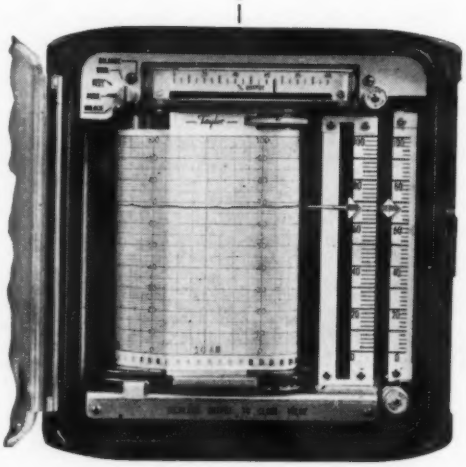

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GENERAL ELECTRIC

patent reviews

By MELVIN NORD, Patent Attorney, Detroit, Mich.

Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C. at 25cents . . . patents reviewed cover period October 27, 1959 to November 24, 1959

PREPARATION OF MATERIAL FOR SINTERING

△ U. S. 2,914,395, issued Nov. 24, 1959, to William Davies and assigned to The United Steel Companies Ltd. provides a method of preparing material for sintering, to decrease its tendency to collapse on the sintering grate.

As shown in Figure 1, the constituents to be mixed are fed from bins 1, 2 and 3 to an endless gathering belt 4. While on this belt they are sprayed with an aqueous suspension of bentonite delivered through spray nozzles 5. This suspension is distributed throughout the material by a series of ploughs 6. The material then enters a rotary mixing drum 7 having internal lifters 8.

Powdered lime is taken from a hopper 9 by a belt feeder 10 to a screw conveyor 11. This conveyor penetrates into the discharge end of the drum 7, so that the lime is sprinkled onto the agglomerates formed in the drum. The agglomerates with their superficial coatings of lime fall through openings 12 in the drum into a hopper 13, and are conveyed from it to a feed device 14 from which they are fed onto a sintering grate 15 to form a bed 16.

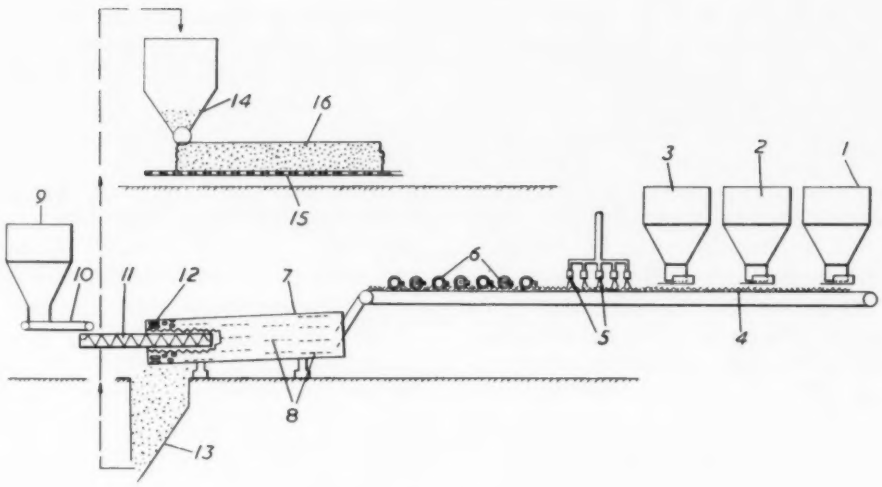


Figure 1

TREATMENT OF SMALL PARTICLE SIZE IRON ORE

△ U. S. 2,911,296, issued Nov. 3, 1959, to Charles A. Long, Jr., provides a process and apparatus for treating small particle size iron ore or combined particles of ore and coke in which the small particles are agglomerated to produce a porous sinter of uniform size.

As shown in Figure 2, the small particle size ore and coke mixture 11 is introduced into the mixer 10 where the particles are thoroughly mixed with each other. The mixture 11 is transferred from the mixer 10 to a hopper 12 and then passes onto the receiving end of the movable grate 13 where it is ignited by the burners 21. As the mixture of ore and coke passes toward the delivery end of the movable grate 13, the downward stream of air imparted by the suction means 22 continues the combustion of the mixture while the mixture is on the movable grate reducing the small iron ore particles into material that can be magnetized. The mixture 11 is discharged from the movable grate 13 into the cooler 23 where the material is cooled. The

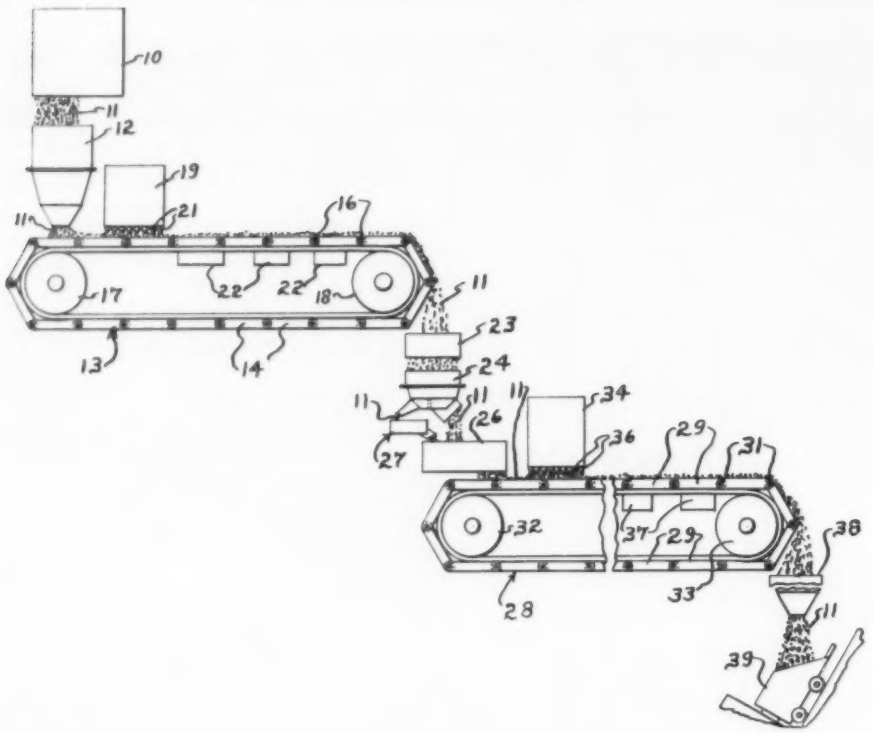


Figure 2

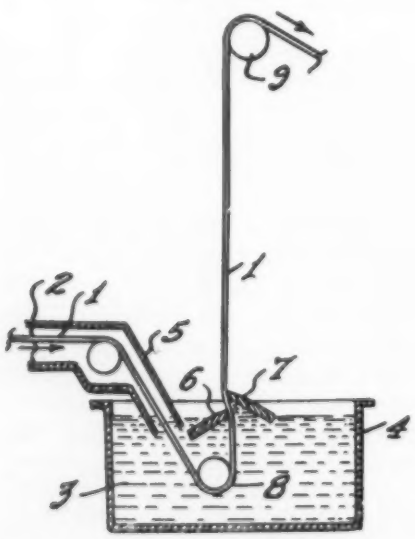
material thus cooled is transferred to the hopper 24 where a portion of it passes through the magnetizer 27 and then into the hopper 26. The remainder of the mixture in the hopper 24 passes directly to the mixer 26. In the mixer 26, the magnetized mixture is mixed intimately with the unmagnetized portion of the mixture and is then introduced onto the receiving end of the movable grate 28 where it is ignited by the burners 36. The updraft of air imparted by the blowers 37 continues the combustion of the mixture while the mixture is on the grate 28. By providing an updraft of air, the intense heat is blown upwardly away from the sintering grate sections 29, thus increasing greatly the life of the grates. As the ore and coke mixture 11 is being transferred along the movable grate 28, the magnetized portion of the mixture 11 attracts the unmagnetized portion resulting in a magnetically fixed mixture of units approximately one in. in diameter; then the intense heat causes the particles of the mixture to be agglomerated and fused together. From the movable grate 28, the mixture is transferred to the storage hopper 38 where it is dumped into skips 39 for transferring the material into the upper end of the blast furnace 41.

CONTINUOUS COATING STRIP

△ U. S. 2,914,419, issued Nov. 24, 1959, to Kasimir Oganowski, assigned to Armco Steel Corp, describes a method of continuously coating iron or steel strip or wire with aluminum or other metal.

As shown in Figure 3, strip 1 passes through a cooling hood 2 and into a bath of molten metal 3 in a vessel 4, through a bell 5 which dips beneath the surface of the molten coating metal and therefore protects the strip 1 from oxidation. The edged lips or pressure members 6 and 7 are displaced vertically with respect to each other and exert pressure against the strip 1 so as to deflect it in its vertical travel. The strip is tensioned between a lower roll 8 and an upper roll 9.

Figure 3



CONTINUOUS REMOVAL OF SCALE FROM HOT-ROLLED PRODUCTS

△ U. S. 2,913,808, issued Nov. 24, 1959, to Ernst Thomas and Bruno A. Hemer assigned to Thomas, describes apparatus for the continuous removal of the scaly matter from hot-rolled, band-like iron products.

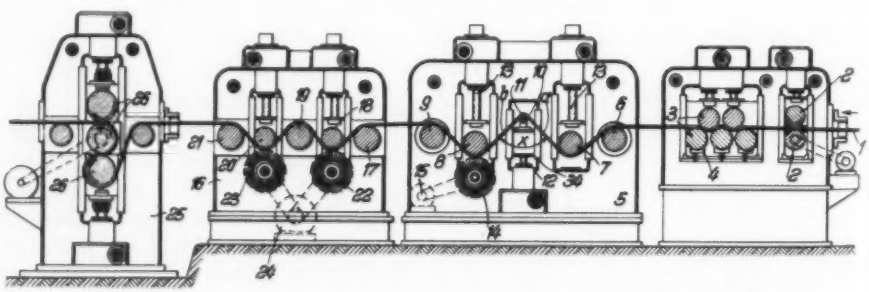
As indicated in Figure 4, the band-iron is drawn over guide rollers and over slide-bars provided with arc-shaped slide surfaces. The slide bars and guide rollers are adjustably supported in their position and arranged with respect to one another in undulating or zigzag-like fashion. The scaly matter is loosened from the band-iron by means of a slide-bar arranged in the vertex of a deflecting angle of the iron products.

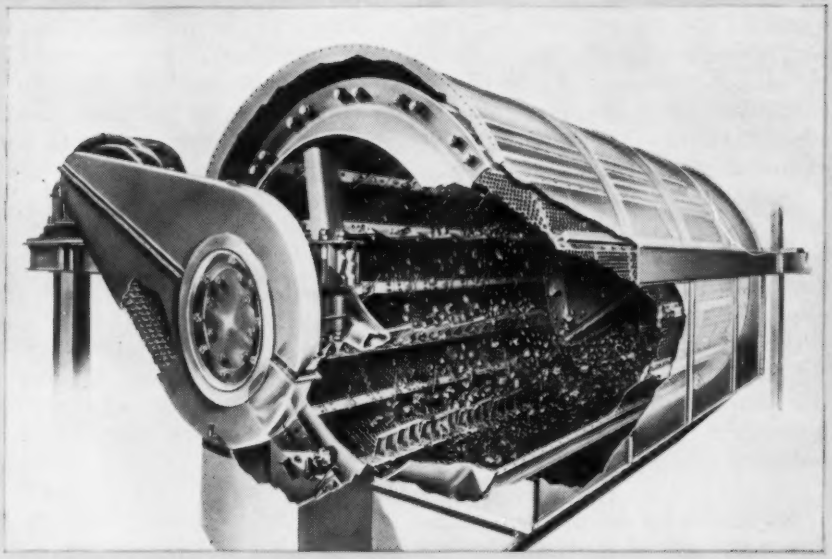
STRIP PROCESSING MECHANISM

△ U. S. 2,913,809, issued Nov. 24, 1959, to John C. Bongiovanni, assigned to The Osborn Manufacturing Co., describes a method of removing scale from hot rolled products, by flexing the work about a relatively small radius, as shown in Figure 5.

In addition to removing a large portion of the scale, the abrupt

Figure 4





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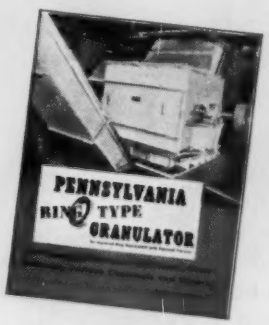

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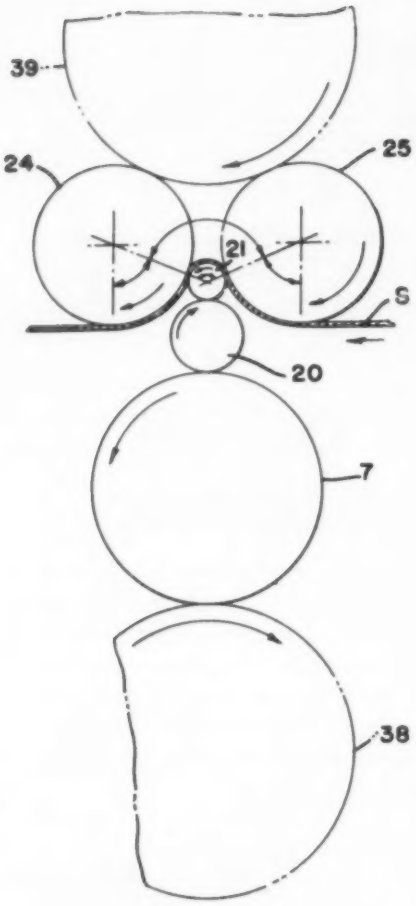


Figure 5

reverse bending of the strip regularizes the metal structure to a considerable extent and superficially work-hardens the strip a little although not enough to prevent the metal from still drawing well. Not only does such abrupt reverse bending exert large edgewise compressive forces on the scale layers, but it also serves to cause minute slivers in the surface to stand up in a manner rendering them more amenable to the subsequent brushing operation.

METALLIC COATING OF WIRE

△ U. S. 2,914,423, issued Nov. 24, 1959, to Earle L. Knapp, assigned to Armco Steel Corp., describes a method of continuous coating of wire with a metallic coating.

It is an object of the present invention to provide a method for coating a strand whereby reflux of coating metal into the bath is minimized or avoided, but without physically contacting the stand with anything in the nature of a lip, wiper or scraper.

In Figure 6, a coating pot reservoir 11 is indicated, having a number of individual pot extensions 12. Conventional means are provided for heating the reservoir, manifold and pot extensions. Dams may be provided so that an individual pot extension 12 may be disconnected from the manifold 11, when it is desired to cut out a strand, or to rethread, or the like.

In each of the extensions 12 there is an orifice 13 and the bottom of the pot at 14 slopes away in all directions so that the bottom is in effect in the form of a shallow cone with the orifice 13 at its apex.

The wire 15 is pulled upwardly to the bath, through the orifice 13, preferably coming to the pot in a reducing atmosphere within hood 19.

Molten metal is in effect pulled upwardly out of the bath by the moving wire. In order to provide for successful high-speed operation, means must be provided to prevent heavy oxide and excess coating metal from being drawn up in a meniscus around the wire issuing from the top of the coating bath and being carried off as an accumulation on the surface of the wire.

To control the amount and distribution of coating metal on the wire, there is provided a combination of two elements. The first of these is an anchoring plate and is made of a material which is wetted by the molten coating metal. The anchoring plate 21 may, for example, be of steel or cast iron or, for minimum iron pick up, it may be made of titanium bearing cast iron or preferably of molybdenum.

The other part of the control element is indicated at 22 and is made of a material which is not wetted by the molten coating metal. The member 22 is of a ceramic material such as, for example, zirconium silicate, porcelain, fire clay, or even an oxidized steel surface coated with lime.

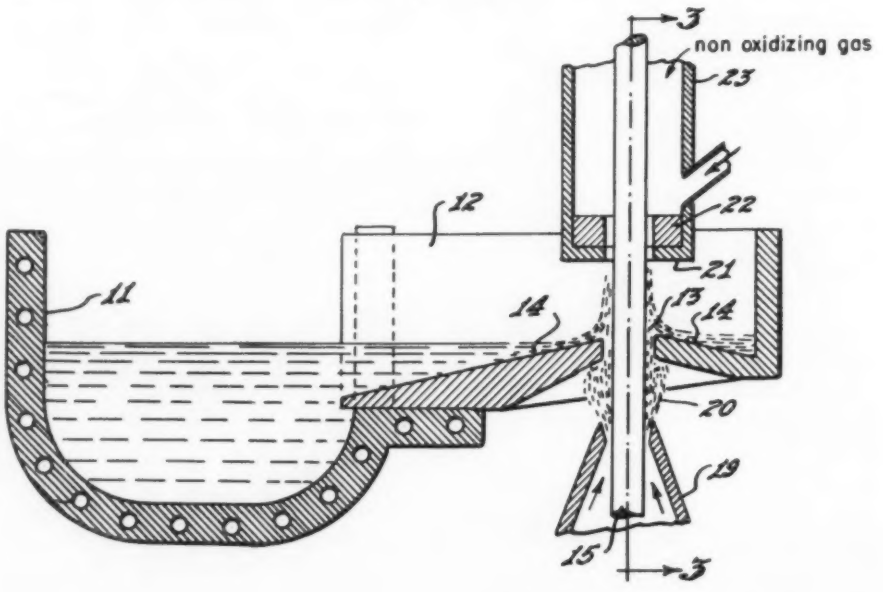
Immediately upon issuing from the control element 22, the wire strand 15 is caused to pass through a chamber 23 through which is passed a nonoxidizing gas so as to insure that the coating has become dimensionally stable before it comes into contact with the atmosphere. Thereafter any oxide coating which is formed cannot disturb the surface finish.

DEVICE FOR MARKING TRAVELING STRIP

△ U. S. 2,913,978, issued Nov. 24, 1959, to John R. Lane and assigned to United States Steel Corp., describes a device for marking traveling strip, which applies only a single mark on the strip each time it operates, thereby eliminating any tendency for the marks to overrun the sheet containing a pinhole, or unnecessarily defacing even this sheet.

In a typical installation, the marker is located between a pinhole detector and a shear which severs the strip into sheets. When a pinhole in the strip passes the detector, the latter completes a circuit which momentarily energizes the solenoid winding 18, as shown in Figure 7.

Figure 6



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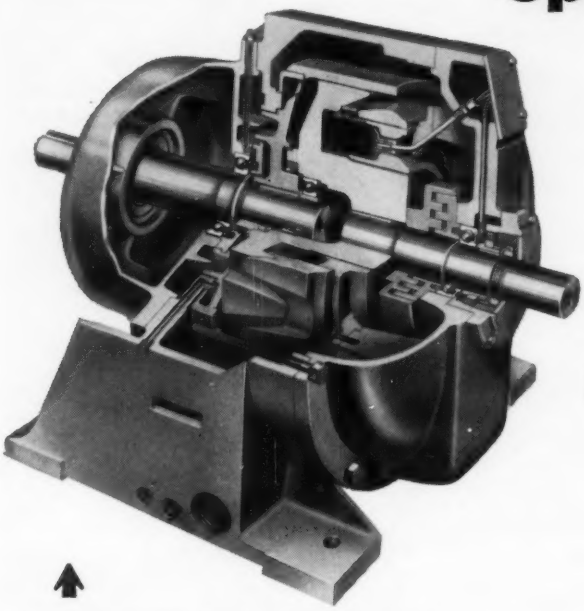

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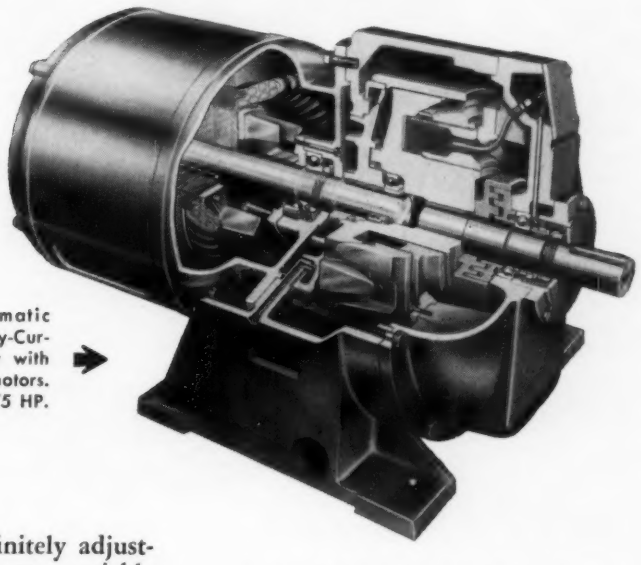

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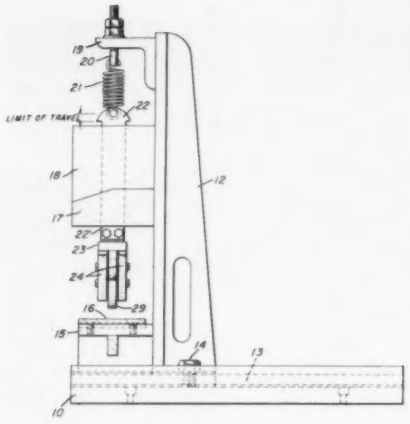


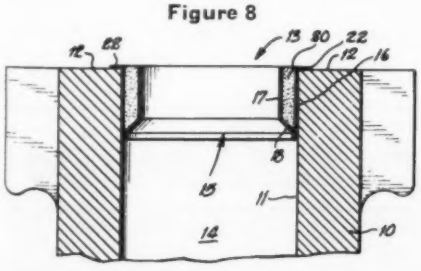
Figure 7

When the solenoid winding 18 is energized, the plunger 22 moves downwardly a limited distance against the action of the spring 21. This distance is controlled by stop means within the solenoid, and is not far enough for the marking wheel 29 to contact the strip S. Since energization is only momentary, the spring quickly pulls the plunger back. As the plunger moves downwardly, the link 23, carrier 24 and marking wheel 29 of course move with it. As the plunger returns, inertia continues to throw the carrier and marking wheel downwardly about the pivotal connection to the link and against the force of the spring 28. The marking wheel contacts the upper face of the strip and commences to apply a mark thereon. However, compression in the spring 28 is adjusted so that the carrier and wheel quickly rebound after the latter contacts the strip independently of the return motion of the plunger. Therefore the mark on the strip is of short length and there is little likelihood of its overrunning the sheet actually defective.

SHEET METAL HOT TOP

△ U. S. 2,913,786, issued Nov. 24, 1959, to Walter M. Farnsworth and Jack H. Kennedy, assigned to Republic Steel Corp., provides a sheet metal hot top and a method of using exothermic material in pouring ingots.

Figure 8



Shown in Figure 8 is an ingot mold 10 for receiving molten metal, provided with an inner wall 11 and top portion 12, the molten metal being received through the opening 13 in the top of the mold. Disposed in the upper part of the mold adjacent the top 12, is a container 15.

The bottom wall 18 slopes upwardly from the outer wall 16 to the inner wall 17. The walls of the container may be made of 28-gage steel.

INGOT MOLD INSERT MAT

△ U. S. 2,910,747, issued Nov. 3, 1959, to Harrison D. Sterick and William E. Schmertz, provides a strip metal flat coil ingot mold insert mat, which is prevented from being pushed up into the shape of a cone.

As shown in Figure 9, a metal strap is put around the mat just to one side of the diameter before the end of the mat is welded and while the mat is still on the winding machine. The ends of this strap are securely locked together, after which the mat is removed from the forming machine and the end of the strip is welded to the outermost convolution in the manner above described. The strip so positioned at one side of the diameter will securely hold the mat from uncoiling or from coning out.

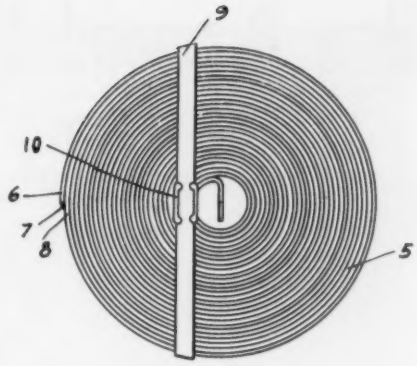


Figure 9

DESULPHURIZATION OF IRON

△ U. S. 2,912,319, issued Nov. 10, 1959, to Olav Moklebust, assigned to National Lead Co., describes a method of desulphurizing iron prepared by low-temperature (900 to 1200 C) operations.

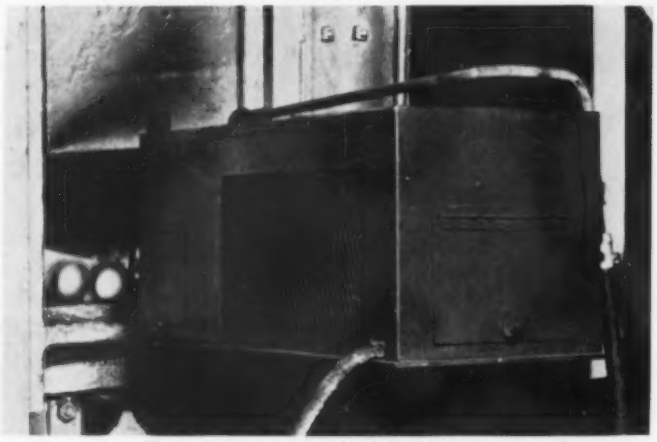
The reduction is carried out without the addition of a desulphurizing agent. After reduction, the desulphurizing agent, limestone, is added to the mixture of reduced ore and coke during the cooling of the mixture. A desulphurization equal to that obtained when limestone accompanies the material through the furnace, is achieved, without the disturbing sintering which normally occurs. Also, the heat necessary for calcination of the limestone is saved, since it is recovered from the reduced material during cooling.

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

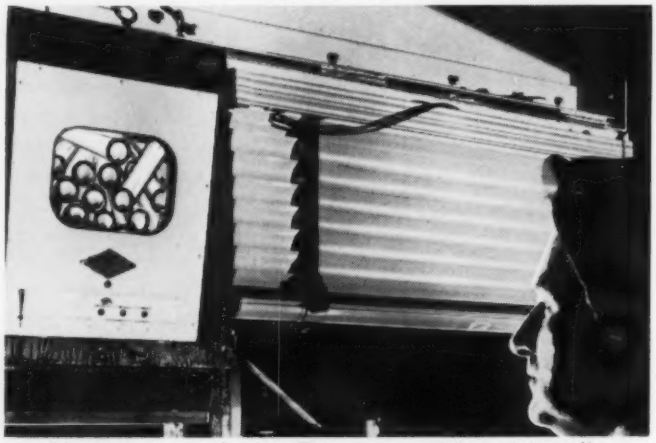
Patent No.	Date	Subject	Inventor or Assignee
2,910,355	10/27/59	Production of molybdenum containing iron and steel alloys	Latrobe Steel Co.
2,910,422	10/27/59	Continuous electroplating of strip	United States Steel Corp.
2,910,746	11/3/59	Tilting ladle	Koppers Co., Inc.
2,911,164	11/3/59	Pivot mounted apparatus for handling coils of strip material	National Steel Corp.
2,911,804	11/10/59	Rolling mill coupling	United Engineering & Foundry Co.
2,911,864	11/10/59	Rolling mill	Emil A. Nelson
2,911,865	11/10/59	Apparatus for making formed wire	United States Steel Corp.
2,912,098	11/10/59	Belt conveyor	United States Steel Corp.
2,912,740	11/17/59	Method of retarding disintegration of blast-furnace linings	United States Steel Corp.
2,913,173	11/17/59	Apparatus for counting bundles moving along a conveyor	United States Steel Corp.
2,913,354	11/17/59	Continuous method for conditioning wire	Northwestern Steel & Wire Co.
2,913,785 & 2,913,788	11/24/59	Casting of ingots	Robert E. Kramig, Jr.
2,914,396	11/24/59	Production of chrome-nickel stainless steel	Washington Steel Corp.
2,914,400	11/24/59	Wrought machinable tool steels	Vanadium-Alloys Steel Co.
2,914,401	11/24/59	Alloy steel	Crucible Steel Co. of America
2,914,434	11/24/59	Controlling atmospheres while heat treating steel	Harold L. Snavely

How Diamond TV cuts costs for Timken Company

"Utiliscope"® *pays for itself in just eight months*

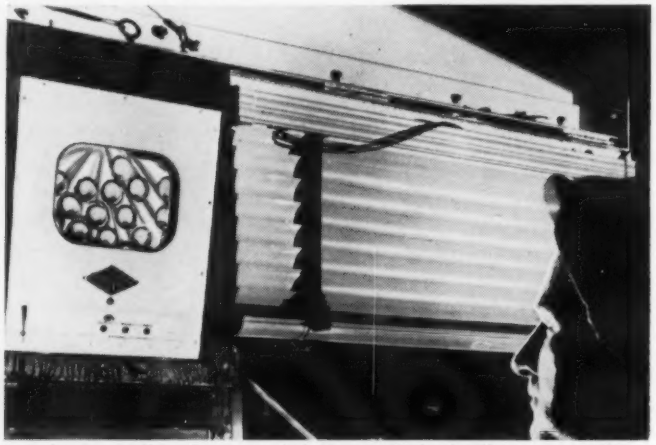


1 Air-cooled TV camera peers inside tube-cooling furnace, transmitting continuous picture to dispatcher in control pulpit 100 feet away. Dispatcher checks television monitor image which shows progress of tubes on walking beam conveyor — watches for pile up of tubes at conveyor exit.



2 Dispatcher, monitoring TV screen, spots a tube pile up instantly. Time lag in old method . . . hand signals from man at furnace port . . . could not have prevented piled tubes from gouging furnace refractory lining before conveyor could be stopped. Costly damage is eliminated . . . production efficiency improved!

3 With piled tubes realigned, cooling production continues with conveyor speed adjusted to prevent recurrence. Dispatcher now flips to second "Utiliscope" on adjacent annealing oven — the next step in tube production where tubes are piled cord-wood style.



4 In annealing furnace, tubes are picked off one at a time at back of furnace by powered rollers under dispatcher's control. Here, dispatcher watches for bridging of tubes which can prevent movement onto delivery conveyor. All clear here, again no spotter is required, again production flow is smoothed and protected with extreme accuracy.

In summary, one dispatcher at Timken's Canton, Ohio, Steel Mill now controls with greater overall efficiency: (1) tube mill, (2) tube cooling furnace, (3) annealing oven. Ambients at the camera location are above 125°F. Tube making is a hot process. It is in this hot spot that signalmen, formerly required, had to work. The signalmen are now working on more skilled jobs in relatively cool work areas.

Diamond's "Utiliscope" provides the metals industry the opportunity to eliminate non-productive tasks, centralize production control, reduce waste, increase employee morale, and gain new operating safety.

Our trained application engineers know the problems of providing effective trouble-free service in hot, tough, dusty locations. They are available to you as assistants in your analysis of the application of television to your open hearth, oxygen process, slab reheat, melting tables, strip mills, shears, raw materials, handling, pouring . . . or any of the other more than thirty known applications.

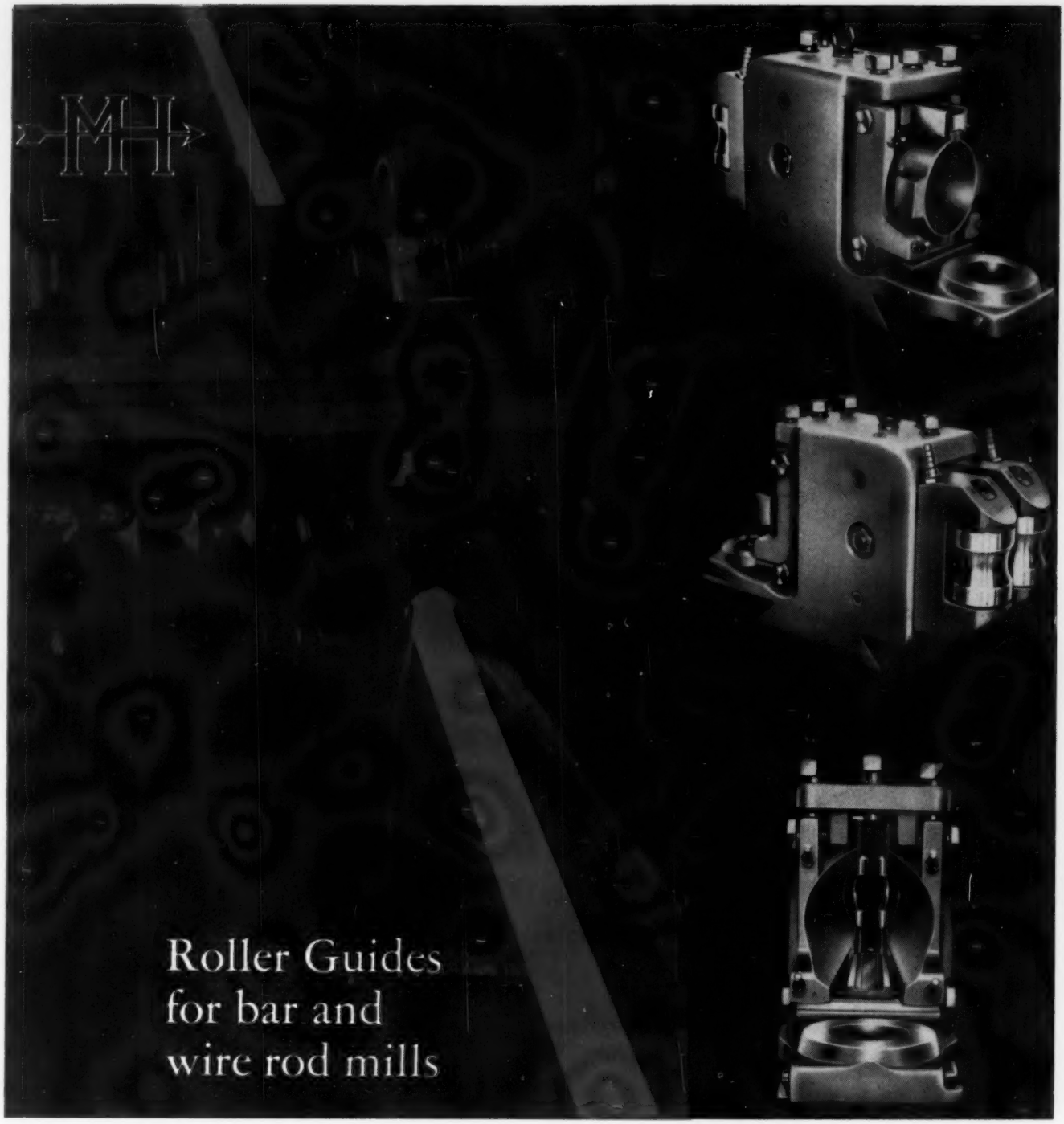
Why not request Field Survey FS33A today? Phone Lancaster, Ohio, OLive 3-6540 or TWX 490.

HELP WANTED . . . *Challenging opportunities available at Diamond Electronics for physicists, electronic and mechanical engineers. Contact C. H. Thomas, Technical Personnel.*

Diamond® Electronics

DIVISION OF DIAMOND POWER SPECIALTY CORPORATION

LANCASTER, OHIO



Morgårdshammar roller guides can be used for many sections such as leader and break-down ovals, squares, hexagons and octagons.

They can handle dimensions from about 3/16 in. (5 mm) round up to nearly 8 in. (200 mm).

You will obtain the following advantages with MH roller guides:

- INCREASED ACCURACY
- LESS SCRAP AND COBBLES
- REDUCED OPERATING COSTS
- INCREASED OUTPUT

For further information please apply to us for catalogues.

P.S.
In Scandinavia every bar and wire rod mill uses Morgårdshammar roller guides.

Sole agent for the U.S.:
K. W. Atwater Engineering, Inc.
124 Grant Avenue
PITTSBURGH, Pa.

Swedish Quality

MORGÅRDSHAMMAR
MORGÅRDSHAMMARS MEK. VERKSTADS AB • MORGÅRDSHAMMAR

Here's a "before" and "after" bearing problem solved by Bearings, Inc.

A large steel mill customer has six cranes with bridge line shafts equipped with the solid housing pillow blocks shown in the "before" photograph. Whenever one of the line shaft bearings needed to be replaced, the entire section of shaft had to be removed. Maintenance costs and crane downtime were excessive and costly. Our engineers were asked for a solution.

THE PROBLEM: Due to the extremely low base to center of shaft dimension of the original bearing, a conventional split housing, split roller bearing pillow block could not be used.

THE ANSWER: We designed and furnished a special split housing pillow block (see "after" photo) incorporating split bearings and split seals which maintain the original dimensions. These can be installed or replaced on the crane in a fraction of the time formerly required just to dismantle the line shaft.

This is just one of many successful solutions of a tough bearing problem. We can help you solve your bearing problems and supply replacement bearings from the stock carrying branch near you. We're authorized distributors for all nationally known bearings. Call us!

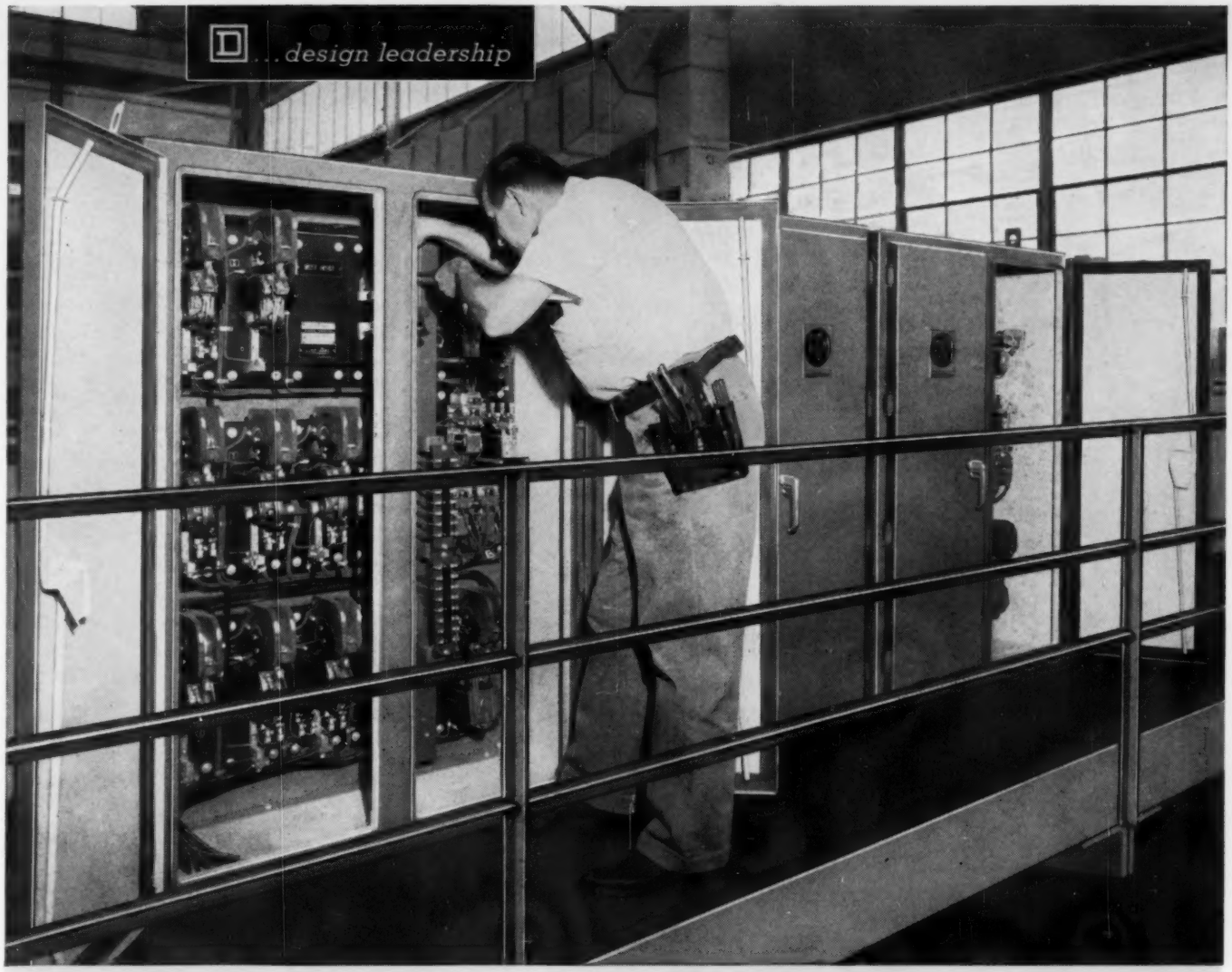
Providing bearing service in the North ➤ **BEARINGS, INC.**

OHIO: Akron • Canton • Cincinnati • Cleveland • Columbus • Dayton • Elyria • Hamilton • Lima • Lockland • Mansfield • Painesville • Toledo • Youngstown Zanesville • **INDIANA:** Ft. Wayne • Indianapolis • Muncie • Terre Haute • **PENNSYLVANIA:** Erie • Johnstown • Philadelphia • Pittsburgh • York **WEST VIRGINIA:** Charleston • Huntington • Parkersburg • Wheeling • **NEW JERSEY:** Camden • Newark **NEW YORK:** Balanrol Corp., Buffalo • Niagara Falls • **MARYLAND:** Baltimore • **DELAWARE:** Wilmington

and

in the South ➤ **DIXIE BEARINGS, INC.**

FLORIDA: Jacksonville • **GEORGIA:** Atlanta • **KENTUCKY:** Louisville • **LOUISIANA:** Baton Rouge • New Orleans **N. CAROLINA:** Charlotte • Greensboro • **S. CAROLINA:** Greenville • **TENNESSEE:** Chattanooga • Kingsport • Knoxville • Nashville **VIRGINIA:** Norfolk • Richmond



NEW! EC&M Front-Connected DC Control reduces catwalk width up to 20 inches

• When space is important, EC&M front-connected control can save you up to 20 inches of catwalk width. Moreover, the controllers are 10% to 15% lighter, can be backed up against girders. The result—a reduction in crane weight.

These new front-connected controllers provide the easiest maintenance of any available. All wiring and control components are accessible from the front, with ample working space inside the cabinet.

You get extra safety, too. Control components are mounted on insulated bases which in turn are mounted on panel studs projecting from the rear of the cabinet. The result is maximum insulation to ground.

EC&M front-connected control is available for single-motor DC drives up to 225 hp, with 2, 3 or 4 decks to suit headroom requirements. Includes exclusive Wright dynamic lowering circuit which gives maximum hook speed without danger of overspeeding.

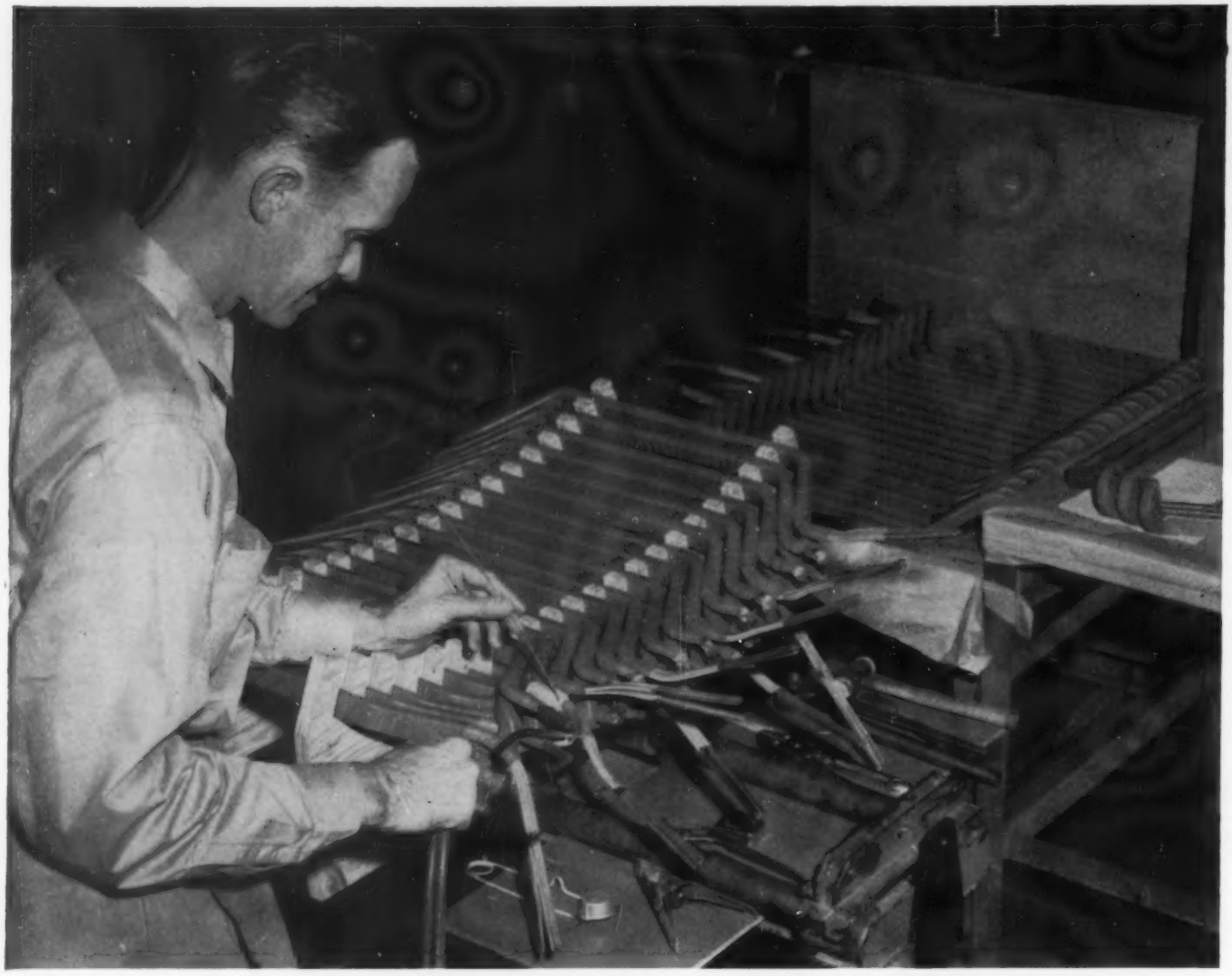
Write for Bulletin 6121. Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio

SQUARE D COMPANY

EC&M DIVISION • CLEVELAND 28, OHIO

wherever electricity is distributed and controlled

4160



Save motor repair time with silicone rubber coils from National

... The Specialists in electric coils/repair service

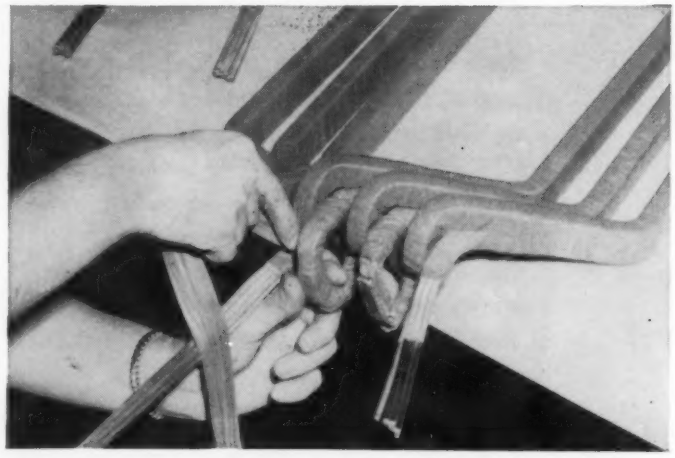
When rewinding motors—particularly those in wet, abrasive or conducting-dust applications—consider the advantages of silicone rubber insulation. Silicone rubber is resistant to water and chemical fumes and is tough and abrasion resistant.

When you order silicone rubber insulated coils from National, you'll enjoy these general advantages of longer life and reduced maintenance—*plus* these special National features:

—National custom makes each coil to exact dimensions, thus ensuring easy installation and eliminating the need for slot liners.

—National uses silicone rubber for insulating the connections so there are no weak points in the system.

Get National's recommendations. Since we either make or use all types of insulation, our recommendations are impartial—based solely on what's best for your application. For more information, call our Columbus plant, HUdson 8-1151, or the nearest National field engineer.

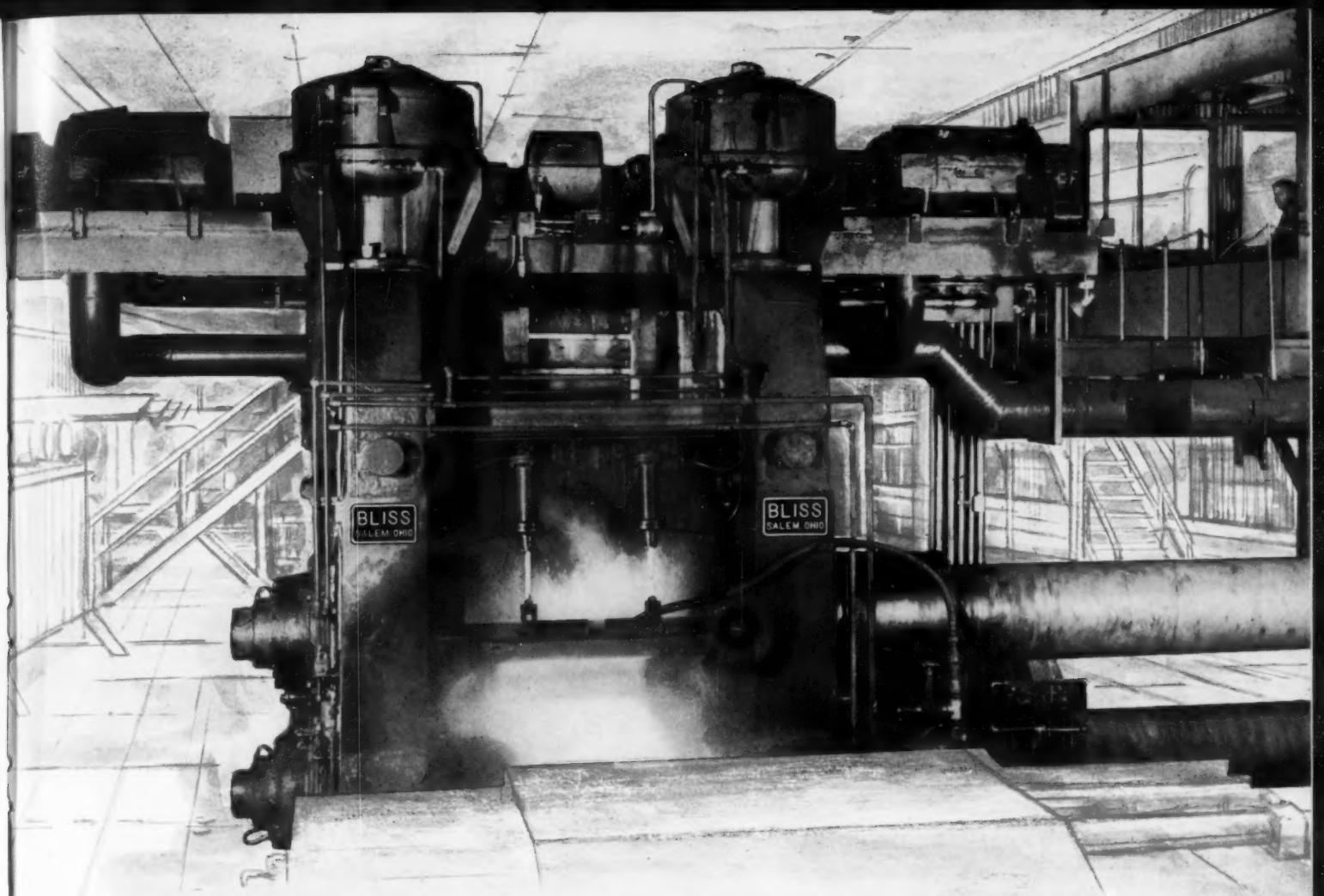


Insulating of connections with silicone rubber insulation.

National Electric Coil

DIVISION OF McGRAW-EDISON COMPANY • COLUMBUS 16, OHIO

Electrical Engineers • Manufacturers of Electrical Coils, Insulation, Lifting Magnets
Redesigning and Repairing of Rotating Electrical Machines



Empire-Reeves changes one mill stand, gains 85% boost in hot strip capacity

The famous hot strip line at the Mansfield, Ohio plant of Empire-Reeves Steel Corporation... the first mill in the world to roll fine-gage strip from ingot in a straight line without a reheat... has just had its capacity practically doubled by replacing a three-high one-way intermediate roughing mill with the new Bliss 38" x 52" reversing mill shown here.

Before the addition, the line averaged fifteen 4-to-5-ton ingots per hour. With the new Bliss mill, capacity ranges to 28 to 30 ingots per hour. Five-inch slab coming from the slabbing mill at the head of the line is reduced to ½-inch, where formerly the slabber had to roll the ingot into ¾-inch slab before the single pass through the old intermediate rougher.

Efficiency of the new mill is further enhanced by the use of a control system that automatically resets the mill between passes at the touch of a button.

Besides the new mill, Bliss' Rolling Mill Division built and installed a new shear that crops the strip ends before the strip enters the finishing train, and provided the new expanding-mandrel type downcoiler at the end of the line.

Whether you're interested in a single mill or a complete rolling plant, you'll find that the Bliss Rolling Mill Division will bring a sharp insight to your special rolling problem . . . an insight that can translate mill design and layout into striking new economy and efficiency. For examples of its work, write today for a free copy of the new 84-page Bliss Rolling Mill Brochure, Catalog 40-B.

BLISS
SINCE 1857

Bliss is more than a name . . . it's a guarantee

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Subsidiary: The Matteson Equipment Company, Inc., Poland, Ohio

Passes even the "white glove" inspection—thanks to new standards of cleanness by Dow Industrial Service

You may never have occasion to apply "white glove" requirements to the cleanness of your process equipment, steam generators, tanks and piping. But, if you do need this high degree of cleanness, Dow Industrial Service can offer it — as an additional service — in the chemical cleaning of *your* plant equipment.

These new standards were developed by Dowell for cleaning the piping networks of the missile launching facilities at Cape Canaveral. Combining the research and engineering facilities of the entire company, new techniques, materials and equipment were perfected to meet the necessary rigid specifications.

This new service is now adaptable for use in all types of American industry. For example, an intricate cleaning job was recently performed on a 3½-mile-long buried pipeline. The customer wanted to convert the six-inch line from hydrocarbon gas to carry oxygen. For this pure product the line had to be immaculate—free of all foreign materials. The plant was faced with the alternate of laying new pipe—a six week job at a cost of $150,000.

Using the new standards of cleanness, the line was cleaned of hydrocarbon residues, carbon black, grease, mill scale, and rust. The cleaning job was done in 3½ days at a cost of $20,000. Meanwhile, plant crews made mechanical alterations to the line at a cost of about $25,000.

The job was satisfactory in every way. Inspection showed the line was free of all foreign matter. The customer credited the job with saving them about $100,000. Also the plant made additional profits because the line was put back into use so quickly.

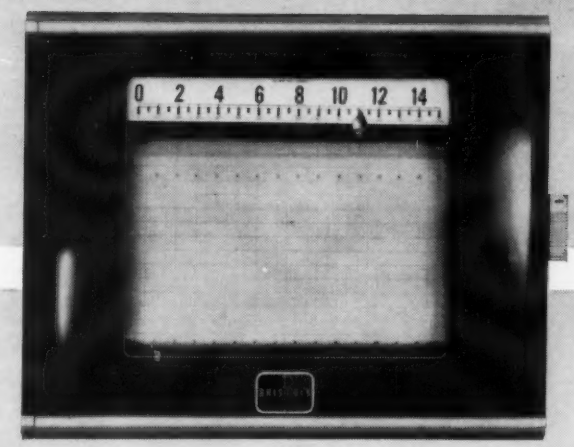
Ask about these new standards of cleanness and their possible application to your problems. This exclusive service may save you important money. Dow Industrial Service offers the cleaning services formerly provided by Dowell. For engineered recommendations or more information, call the office or station near you. Or write Dow Industrial Service, 20575 Center Ridge Road, Cleveland 16, Ohio.

Chemical Cleaning Services for all industry

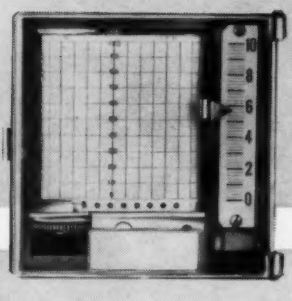
DOW INDUSTRIAL SERVICE

DIVISION OF THE DOW CHEMICAL COMPANY

DOW

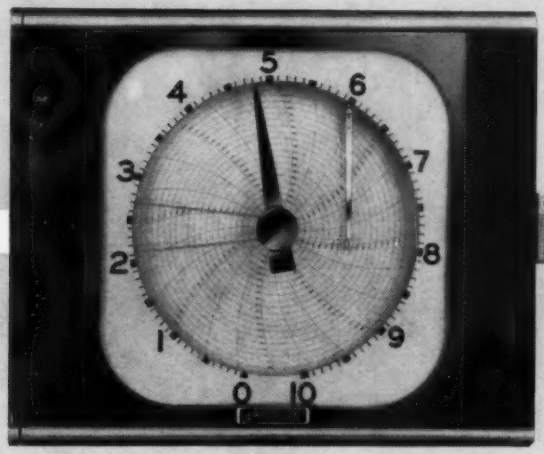


Dynamaster Electronic Potentiometer Pyrometer—Strip-chart model records on chart 11" wide, 120' long.



Miniature Electronic Dynamaster Pyrometer—Records on 3" strip-chart. Indicator model features easy-to-read 9" scale length.

Bristol Millivoltmeter Pyrometers—Free Vane* pyrometer controllers (shown) or indicating types. Many control modes available.



Dynamaster Electronic Potentiometer Pyrometer—Round-chart model records on 12" chart, indicates on extra large scale.

MODERN PYROMETERS...key to profitable use of HEAT

Bristol recording and automatic controlling pyrometers for temperatures up to 5000° F can help you increase product uniformity, cut fuel and maintenance costs

Bristol makes a wide range of pyrometers for every requirement: Electronic potentiometers, millivoltmeter and radiation types . . . for furnaces, ovens . . . every type of heating equipment, every kind of fuel. The reliability and accuracy of these precision instruments have been proved in thousands of installations.

Take just one advanced Bristol instrument, for example, the Electronic Dynamaster* Potentiometer Pyrometer:

CONTINUOUS STANDARDIZATION PLUS ACCURACY OF STANDARD CELL

Continuous standardization in Dynamaster Electronic Pyrometers requires no dry-cells, **but still retains the precision standard cell for highest stability and accuracy of voltage reference.** Results: No interruption to operation, no batteries to change. And here are just a few of the Dynamaster types available:

A model for every requirement: Dynamaster Pyrometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

Electric and pneumatic controllers: Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control—on-off, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control—on-off, proportional, and proportional with reset.

Miniature Dynamaster Pyrometer: Full plug-in flexibility . . . takes only 5" x 5⅛" of panel space, but has same basic accuracy, same time-tested operating principle as full-size Dynamaster pyrometers described above. Ideal for graphic panels and centralized recording or indicating of large numbers of variables. Either electrical or pneumatic control types available.

Write for complete data on Bristol Pyrometers—and remember Bristol offers a complete line of thermocouples and pyrometer accessories. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. *T.M. Reg. U. S. Pat. Off. 9.9

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Down go back-up roll costs with

USS Quality Forged Sleeves

PICTURED ABOVE is James S. Rennick, a metallurgist with twenty years' experience in the Forgings Division of U. S. Steel. Jim specifies composition, heat treatment, and other processing procedures essential to the production of assemblies as shown in the main picture—a back-up roll that will be used in the cold reduction tin mill at U. S. Steel's Gary, Indiana plant.

This job points up a curious situation: U. S. Steel is one of the country's leading manufacturers of rolls, and also one of the biggest *users* of rolls . . . a double reason to perfect their performance and reduce their cost . . . just as we did here.

We had to replace a worn, cast steel back-up roll. Rather than replace the entire roll, we machined the face of the roll and shrunk on a *forged* steel sleeve. For back-up rolls like this one, 42″ O.D. and larger, this method of sleeving is much less expensive than buying a complete new roll. One arbor can be used for several forged sleeves. A forged sleeve has a hard, wear-resistant surface and is highly resistant to spalling.

Also, the sleeve is purposely produced with a softer bore to develop a desirable stress pattern, and to provide maximum gripping between the arbor and sleeve after assembly.

There is a good possibility that we can help reduce *your* roll costs. Write or call the United States Steel Office nearest you, or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

USS is a registered trademark

United States Steel Corporation—Pittsburgh
Columbia-Geneva Steel—San Francisco
Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Export Company

United States Steel

Superex is easily combined with other insulations such as Johns-Manville Thermobestos®, J-M 85% Magnesia or J-M Insulating Fire Brick.

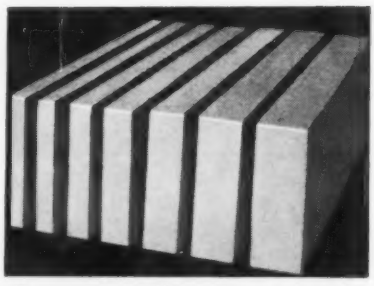
Only Johns-Manville Superex insulation performs 3 ways better at high temperature!

Few industrial products are so outstandingly superior, or so widely used in their area of application, as Johns-Manville Superex® Insulation.

A block insulation formulated of diatomaceous silica and asbestos for furnace and other applications, Johns-Manville Superex brings many advantages to high-temperature service—each contributing to reduced construction, maintenance and operating costs.

Superex is installed with measurable savings in time and labor! It is easy to cut and handle . . . weighs only 2 lbs. per sq. ft. per inch thickness . . . available in a wide variety of large block shapes and sizes. At high temperature—the material's excellent insulating value, thermal stability and resistance to shrinkage keep fuel costs low. Equally important—Superex saves on maintenance, too . . . easily withstands the daily abuse of normal service.

Send for your copy of IN-190A, the 12-page design and technical data brochure. It lists suggested applications—gives complete heat transmission tables and performance data. *Write for it today.* Address Johns-Manville, Box 14, N.Y. 16, N.Y. In Canada, Port Credit, Ont.



Saves waste. Superex comes in 7 standard thicknesses from 1″ to 4″. Other sizes available on order.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

ALLIS-CHALMERS

Allis-Chalmers equipment for progressive mills: **1.** motor, **2.** control, **3.** mercury-arc and semi-conductor rectifiers, **4.** furnace transformers.

The right start for better end results

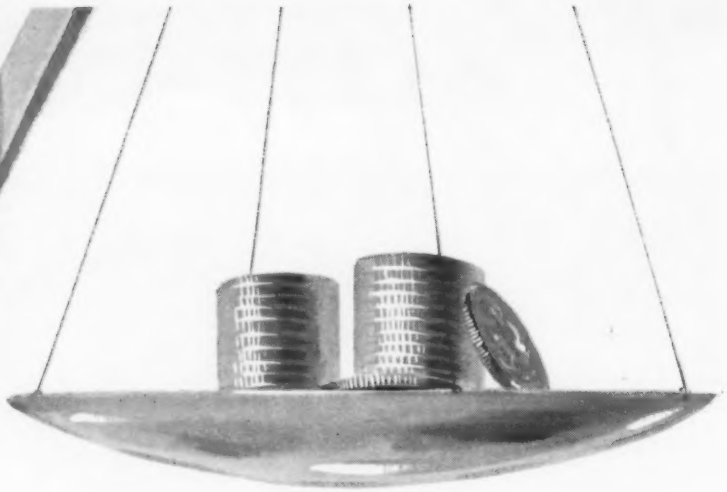
begins with Allis-Chalmers electrical equipment coordination

Proper application . . . efficient use of electric power — these are essential ingredients to peak mill output. No single piece of equipment in a process line can guarantee this result, for its performance depends on the accurate function of other devices.

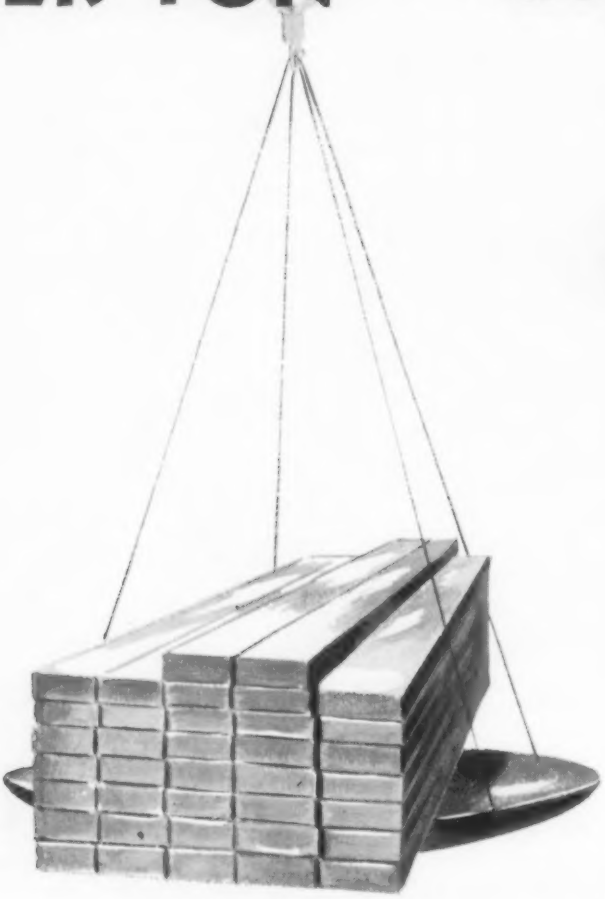
Allis-Chalmers equipment is matched to mill standards for maximum performance. Blooming mills, hot-strip mills — wherever electric power is used, Allis-Chalmers coordinated engineering is the key to higher efficiencies . . . increased yield . . . a finished product of the highest quality.

Allis-Chalmers is helping steel mills with their new plant and modernization programs. Many have improved output and product quality without the cost of major plant alterations.

There's an Allis-Chalmers steel mill specialist near you. *Call him direct, or write* ***Allis-Chalmers,*** *Industrial Equipment Division, Milwaukee 1, Wis.* A-1272



LOWER "COST PER TON" — designed into every MORGAN Rolling Mill



Today's Mill has to be designed for tomorrow's economy—if it is to successfully compete in the cost and quality race of the coming years.

Improve the product, reduce the cost, do it faster—these are all prime requirements of American Industry—and Morgan know-how has some tangible answers to these demands.

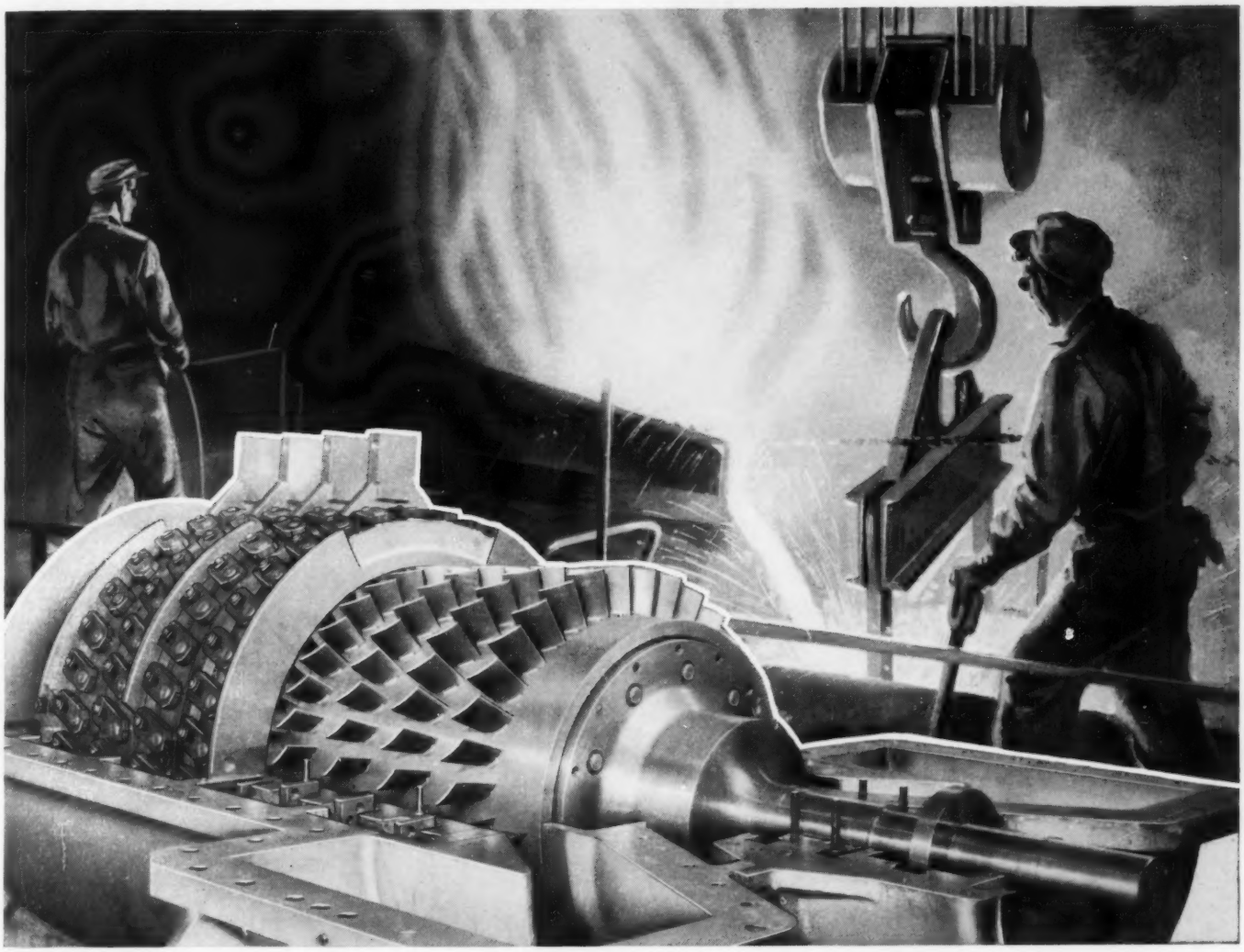
Young engineers with ingenuity, tempered by the experience of older men, bring the greatest advances in Rolling Mill performance to bear on *your* problem.

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS

ROLLING MILLS • MORGOIL BEARINGS • GAS PRODUCERS
WIRE MILLS • EJECTORS • REGENERATIVE FURNACE CONTROL

RM-65

ALLIS-CHALMERS

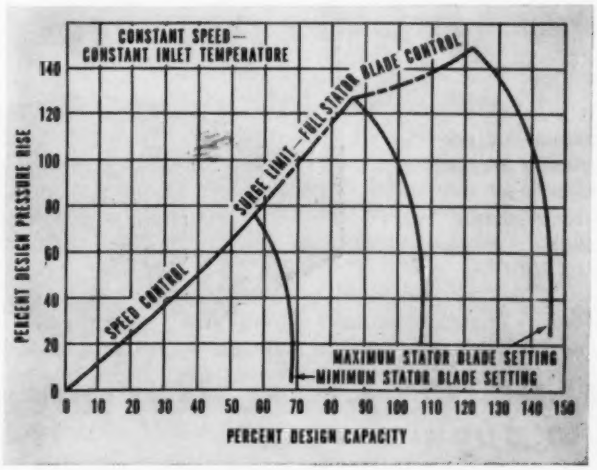


Adjustable stator blade axial compressors from Allis-Chalmers let you

vary wind capacity...cut steam 15%

By simply adjusting stator blades while an Allis-Chalmers axial compressor is operating, capacity can be varied to meet a broad range of operating conditions. A-C axials give high efficiency with practically the same capacity range as centrifugals. Compared to a centrifugal compressor of a similar rating, a 125,000-cfm axial, for example, is *half* the diameter and *one-quarter* the weight! You make substantial savings on reduced handling, foundation and space costs. And operating economies reduce steam requirements as much as 15%. Remember: Allis-Chalmers offers industry's *most complete line of rotating compressors*. You'll get an unbiased compressor recommendation, whether you need single or multi-stage centrifugals, multi-stage axials or sliding vane rotaries.

To see and operate a working adjustable stator blade model, contact your A-C office, or **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wisconsin.* A-1259



- HIGH PURITY
- LOW IRON OXIDE CONTENT

HARBISON-WALKER

HW23LI

insulating fire brick particularly suited for controlled atmosphere furnaces

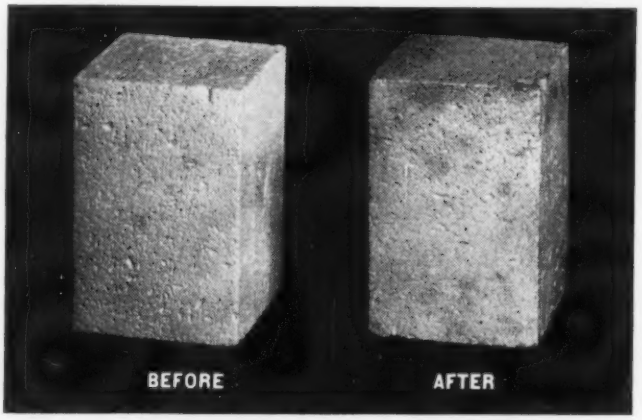
Harbison-Walker H-W 23 LI insulating fire brick produced primarily for controlled atmosphere furnace requirements contains in total not over 2% of accessory oxides, including iron oxide, which are subject to the influence of the usual furnace gas atmospheres. This enhanced property of resistance to the detrimental action of gases is accomplished without any sacrifice of other desirable physical characteristics.

Very low bulk density (27 to 30 pcf), augmented by minute pore size, accounts for its high insulating value. Exceedingly fine texture contributes to desirable glazing and to its good resistance to penetration by volatile fluxes.

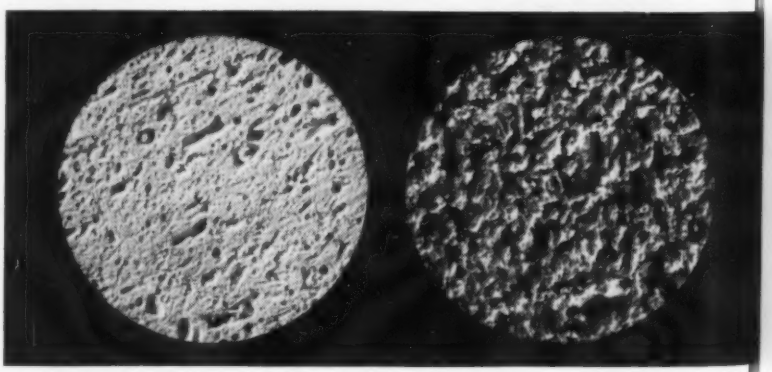
In the prescribed A.S.T.M. 210-46 test for 2300°F. insulating brick, the H-W 23 LI brand, when held at the maximum temperature for 24 hours, shows zero linear change.

The crushing and transverse strengths of H-W 23 LI are adequate for sustaining its weight and the thrust imposed in arches of relatively wide spans, up to its temperature limit.

The optimum combination of physical and chemical properties adapt H-W 23 LI fire brick to a wide variety of uses, in addition to controlled atmosphere furnaces. Write for complete specific information. A sample will illustrate its excellent workmanship.



H-W 23 LI before and after a 500-hour test in an atmosphere of 95% + carbon monoxide (per A.S.T.M.: C288-56), illustrating the high degree of immunity to disintegration by carbon deposition. In this test of long duration at the most critical temperature, H-W 23 LI was unaffected.



Magnification x2, illustrating pore size of H-W 23 LI.

Magnification x2 of another 2300°F. insulating fire brick.

Harbison-Walker insulating products also include all conventional classes for service up to 3000°F.

Modern packaging in sturdy cartons assures safe transportation and efficient handling. Packed 25 to a carton.

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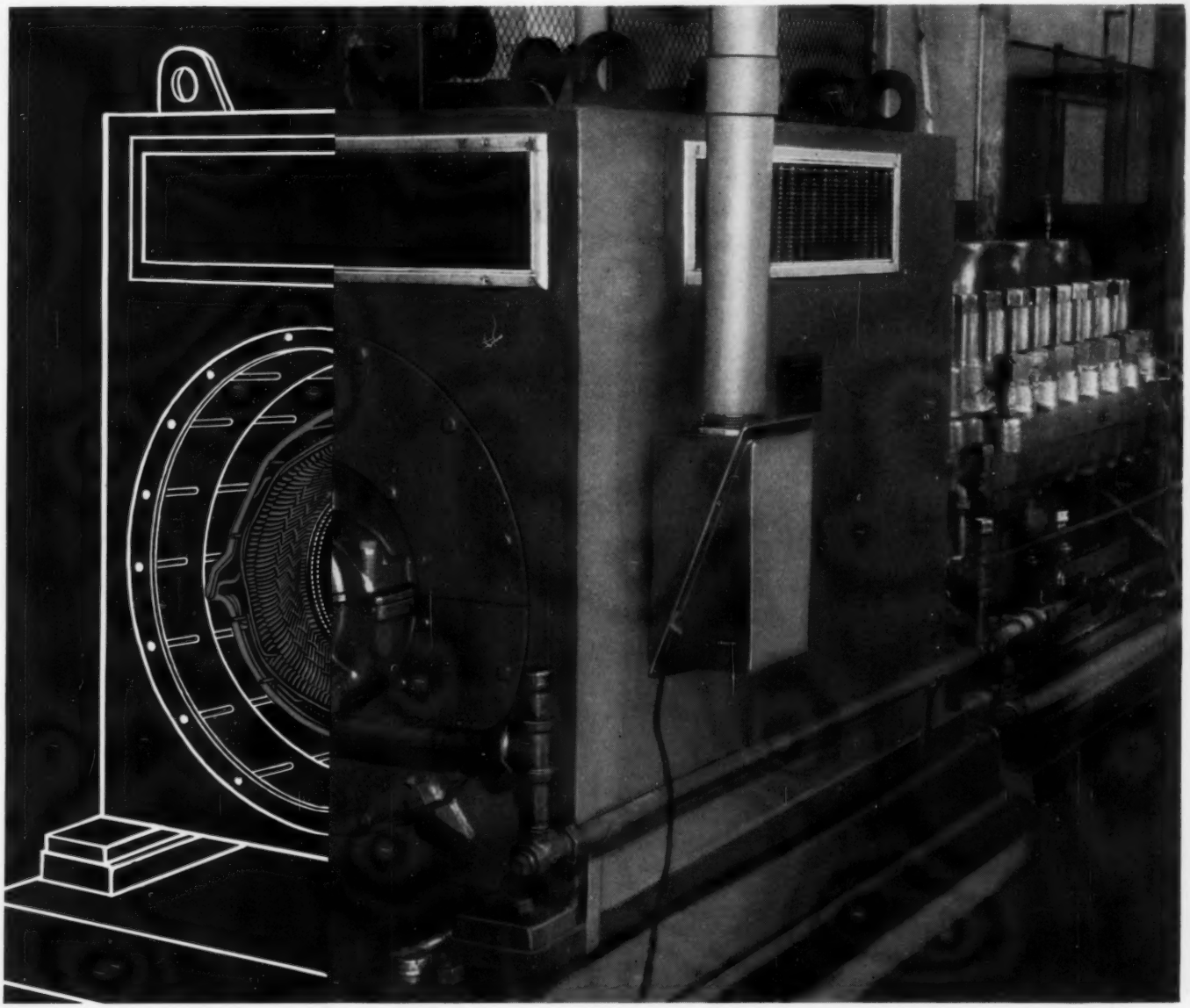

Silco-Flex insulation in this descaling pump application has solved the problem of oil and extreme moisture — two of the worst enemies of motor insulation.

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Silco-Flex insulation, for example, has completely changed the rules on open-motor application. It is impervious to moisture, oils, and most acids, alkalies and solvents. It is resistant to abrasion, and is capable of withstanding high temperatures. Its resilience provides durability to withstand shock and vibration.

Super-Seal motors, with *Silco-Flex* insulation, have proved themselves for more than five years under the most severe conditions in industry.

Advancements such as capsule bearings, split end housings, and *Integrated* field coils (for synchronous motors) add to the superior performance of *Super-Seal* motors.

They contribute to the invisible standards that protect your motor investments year after year — cut replacement costs — assure uninterrupted production.

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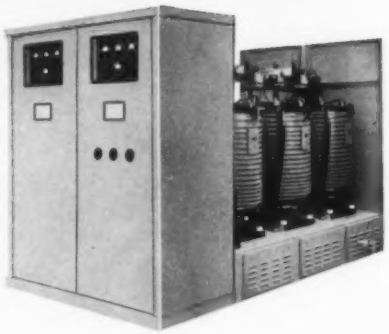

Excitron convertor set with 6 single-anode tanks for d.c. voltages up to approx. 1600 V and continuous currents up to approx. 3,500 A (r.m.s.), maximum currents up to approx. 9,000 A (r.m.s.)
Weight of a mercury-arc unit approx. 440 lb (200 kg)
Weight of a complete convertor set approx. 6,600 lb (3,000 kg).
Area of base 6 ft × 11 ft (1.8 × 3.3m)

26/55 E

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Foreign Digests

Complete translations from which these condensations were prepared are available from Henry Brutcher, P.O. Box 157, Altadena, Calif., to whom all correspondence should be addressed.

"TRIAL OPERATION OF A BLAST FURNACE ON FLUXED SINTER"

by M. INOUE and others, Production Dept., Yawata Iron and Steel Co., Ltd. (Translation No. 4770 from Tetsu to Hagane, Vol. 45, 1959 No. 3)

Δ TRIAL runs using fluxed sinter were conducted on a blast furnace at the Horaoka Plant of the Yawata Iron Works. The furnace had a working volume of 31,400 cu ft and a nominal capacity of 770 net tons per day. The sintering mix contained 10 per cent of limestone. Sinter was varied, forming 40, 60, 80 and 100 per cent of the total ore charge. To eliminate the effect of fluctuations in ore quality, the results were averaged for a 15-day period.

Throughout the period of the trials, the furnace was in good operating condition, but during the last ten days of September the slag notch was damaged on two occasions. As a corrective measure, the amount of iron sand (magnetite ore) was reduced, thus eliminating this trouble.

The results of the trials were as follows:

The addition of 10 per cent limestone to the sintering mix lowers the quality of the sinter. Its loss in strength strongly affects blast furnace operation. Accordingly, the production of a high-grade strong ore sinter is of primary importance.

Increasing the amount of high-grade fluxed sinter facilitates pig iron production, and a high productivity may be obtained at a low coke rate.

By increasing the amount of high-grade self-fluxing sinter, the coke rate can be sharply reduced, especially with 100 per cent sinter burdens.

When fluxed sinter is used, desulphurization of the pig iron is achieved in the furnace, enabling operation at low slag basicity.

The use of high-grade fluxed sinter in large amounts improves blast furnace efficiency. Improving the physical quality of the sinter will require further study.

OTHER AVAILABLE TRANSLATIONS

"**Commercial Vacuum Treatment of Steel for Rolling and Forging Ingots and Castings,**" by K. Brotzmann and others, Stahl Und Eisen, vol. 79, 1959, No. 9. Relative merits of vacuum-lifter (Dortmund-Hörde) and recirculation or closed-circuit (Ruhrstahl) processes. Supplementary data on closed-circuit, Ruhrstahl process. Experimental work done at Huckingen on degassing 40-ton heats in ladle and results obtained. Degassing after filling the mold (Hoesch-Westfalen). Variation of nitrogen content in relation to oxygen content. (Translation No. 4606)

"**Direct Reduction Of Iron Ores,**" by N. N. Dobrokhotov and K. E. Makhorin, Institute for Gas Uses, Ukrainian Academy of Sciences, Izv. Vuz-Chern. Metallurgiya, October, 1958. Russian-developed project for direct extraction of iron by reduction of rich ores or concentrates with water gas obtained by partial combustion of natural gas with oxygen. Prerequisites to erection of large-tonnage plants for direct reduction. Description of a fluidized-bed reactor with a daily output of 1100 net tons: design details and dimensions; operation. Particulars on reduction process; function of the five separate sections of reactor. Data on a shaft-type furnace for direct reduction, of 550 net tons of daily production. Design and dimensions; operation. Calculation of reduction of magnetic oxide by natural gas. Expenditure and composition of gas obtained per weight unit of sponge iron. Cost data and economy of proposed process. (Translation No. 4614)

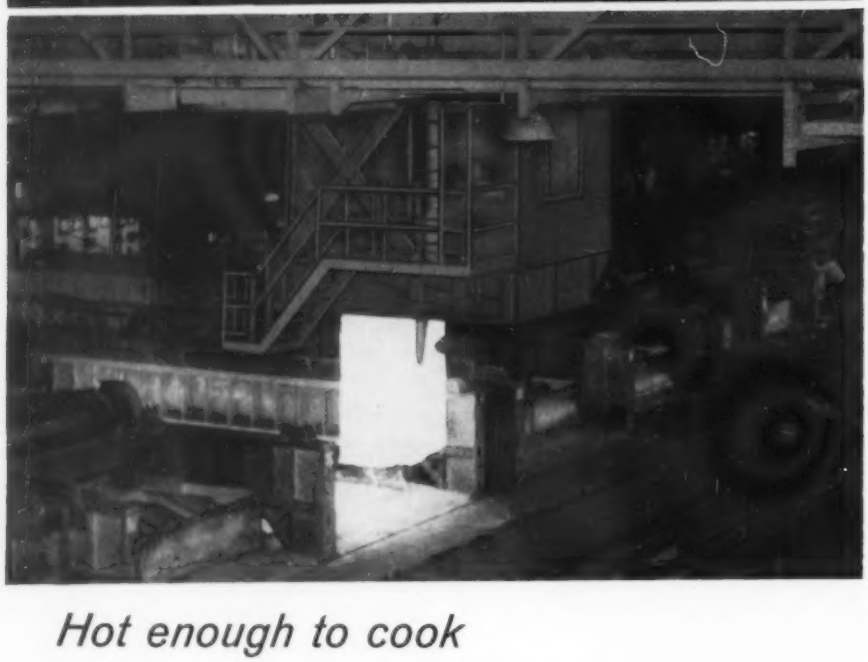
"**Some New Sponge Iron Processes—Part II,**" by M. Wiberg, Jernkontorets Annaler, vol. **142**, 1958, No. 6. Concluding part of a description and evaluation of sponge iron processes of current interest. Shipley (U. S. Steel Corp.) Nu-Iron process; tabulated data on gas volumes and composition. Esso-Little process. R-N process; results of laboratory tests; fundamental work done on process; flowsheet of Birmingham, Ala., plant. Madaras process; Longview, Tex., operation; simplified Monterrey, Mexico, version. Principles of Cavanagh, Canada, Echeverría, Spain, and Aspegren, U. S. processes. Conclusions drawn: unsolved mechanical problems; promise of reduction of

fine-particle ores by gases. General discussion. (Translation No. 4665)

"The Waste Gas Problem in Oxygen - Steel Production—Especially the LD Process," by K. Baum, Berg- und Hüttenm. Monatshefte, vol. 104, 1959, No. 2. Basic facts underlying the problem of waste-gas treatment at steelmaking furnaces using oxygen. Fumes particles wetted with droplets of liquid in Pease-Anthony venturi scrubber; general and specific performance data on this scrubber after five years of development work. Desiliconizing of hot metal in two 45-ton vessels and cleaning the waste gases therefrom; space requirement; stack smoke. Gas cleaning at LD oxygen plants: Process I—direct hot quenching of waste gases; actual water consumption; figures on an LD plant in Holland. Process II—partial indirect cooling of waste gas; special variant of scrubber where water is in short supply. Process III—indirect cooling with full waste-heat recovery boilers; data on water needed for saturation and energy needed for gas cleaning and recovery of iron oxides per ton of metal. Sludge treatment and iron oxide reclamation. Evaluation of the specific advantages of processes. Calculated mean operating data for venturi gas cleaning installation. (Translation No. 4717)

"Gas Heating of Ingot Sinkheads," by K. N. Konovalov, N. K. Korneva, P. M. Danilov, L. I. Teder, T. T. Drobyazko and A. S. Shtepa, Kuznetsk Iron and Steel Works, Stal', vol. 18, 1958, No. 4. Development of a simple gas burner for heating the tops of 6 to 7 net-ton ingots of carbon, low and high alloy steels; development of suitable heating practices and slag cover compositions for minimum oxidation effects. Particulars on design of burner and hot top; operation of burner; best gas mixtures and working pressures. Special precautions to be taken with 18-8 Ti steel ingots weighing seven net tons to prevent titanium loss: oxygen pressures in burner; burner throughput; composition and quantity of slag mix to be scattered over ingot top; best heating times. The experiments with stainless steel gave the following results: The ratio of gas to oxygen flow-rates and the burner throughput decisively affect titanium oxidation and the quality of steel macrostructure. The maximum titanium oxidation loss (35 to 20 per cent) in the sinkhead of an ingot is observed in heating the metal with an insufficient amount of an acid or a fluid basic slag. Introduction of titanium oxides into the slag mixture (in the composition of furnace slag from stainless steel heats) and aluminum powder can compensate for the oxidation of titanium in heating. The minimum top discard (9 to 10 per cent) from rolled stock from experimental ingots, without discard for contraction and rim contamination, is obtained in casting comparatively large ingots in L5 molds with experimental square, well heat-insulated hot top. The macrostructure, mechanical properties and resistance to intergranular corrosion of experimental ingots of 18-8 Ti steel are satisfactory according to routine checks. The additional expenditure on gas heating of stainless steel ingot sinkheads is about one thirteenth of the saving due to reducing the top discard by 6 per cent. (Translation No. 4708)

Although exposed to high ambient temperatures, this cab is easily kept at 80°-85° F. It means safer and better working conditions and improved production.



Hot enough to cook a crane operator

BUT IT DOESN'T HAPPEN HERE!

The man inside this crane cab is fresh and efficient because his cab is Lintern Air Conditioned. In spite of that hot ingot, the operator enjoys a comfortable temperature the year around. He's free of fumes, gases, dirt and the fatigue that excessive heat brings on.

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hundreds of plants have improved efficiency. Right now Lintern is busy modernizing the crane cabs and pulpits of dozens of plants. This means they'll enjoy more output, less labor turnover, a greater return on their capital investment.

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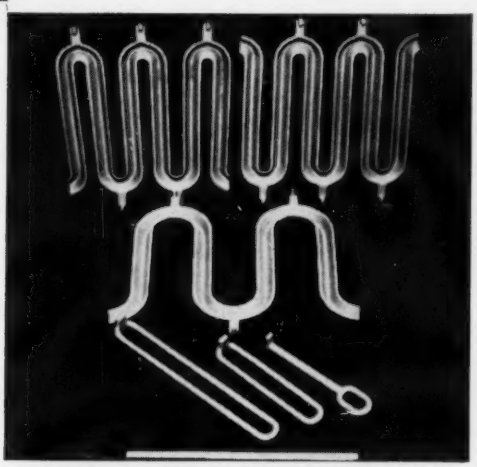
Duraloy Centrifugally Cast Tubes 7'9" long, 7" O.D., ⅜" wall. 28 Cr 10 Ni; some of HOM alloy.



Duraloy Resistance Grids—Shell Molded. 18 Cr 38 Ni; some of special HOM alloy.

Heat treating furnaces need high alloy castings... radiant heat tubes for gas or oil fired... resistance grids for electrical... and castings for handling material through the furnace. *And the castings must be fail-proof!*

One reason—indeed the major reason—why The Electric Furnace Company, Salem, Ohio, has leaned so heavily on Duraloy for its castings is that over the years Duraloy Castings have established a fine record for durability and uniformity. And with the recent development of Duraloy HOM, the furnace company can work towards higher temperature operations. HOM can be used quite broadly at temperatures up to 2200°F and in a limited way to 2300°F. It can be cast statically, centrifugally and shell molded.

When such an authority on heat treating furnaces as Electric Furnace so consistently selects Duraloy castings for these furnaces on which it has built an enviable reputation... that preference suggests quite strongly that Duraloy castings are consistently sound and skillfully alloyed to meet exacting high temperature applications. This same skill offers comparable values to all who require high alloy castings.

Annealing furnace designed and constructed by The Electric Furnace Company used for cycle annealing of enameling iron strip and bright annealing of cold rolled strip. Three methods of heating: direct fuel fire; fuel fired radiant heat; and electric resistance used in the various zones.

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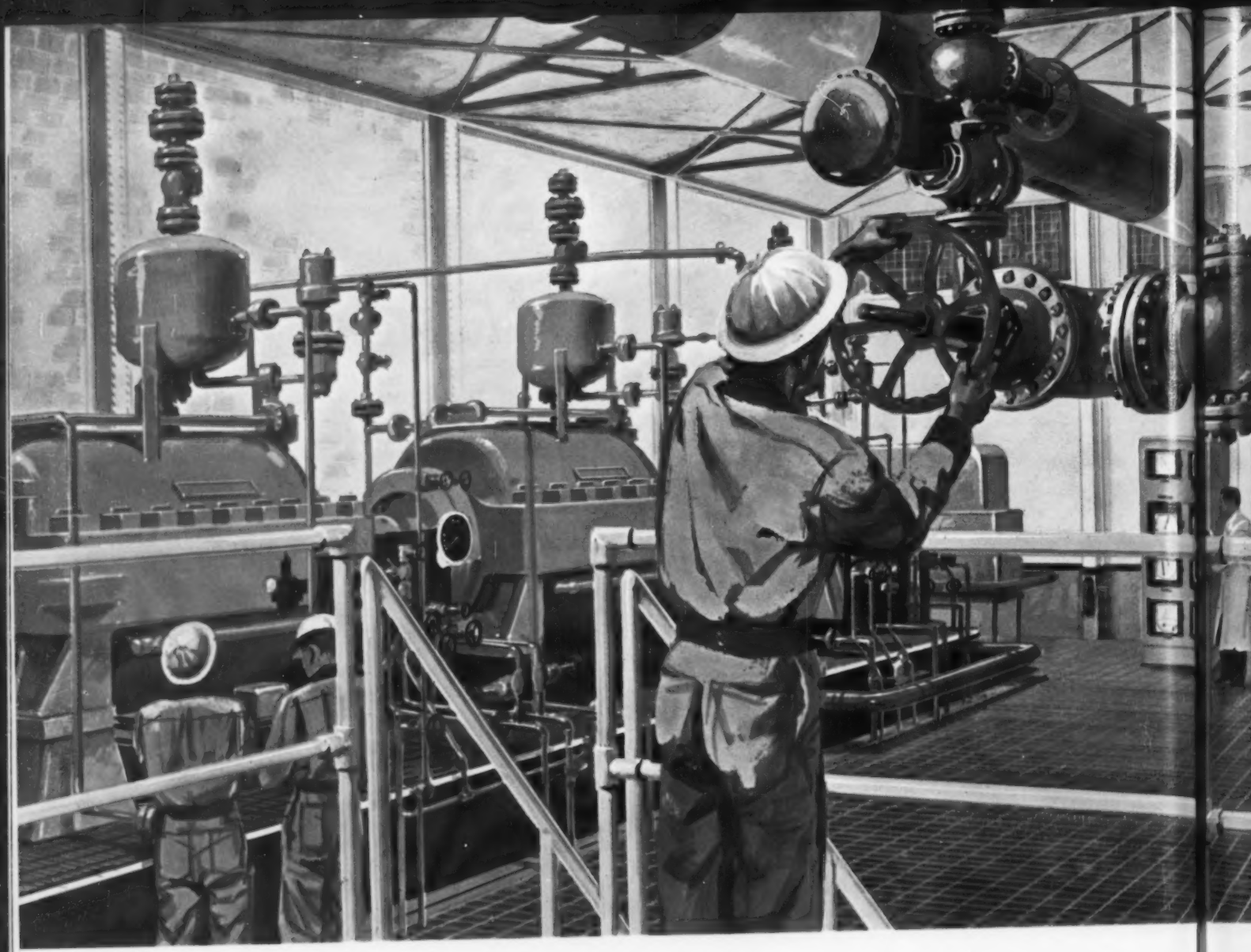
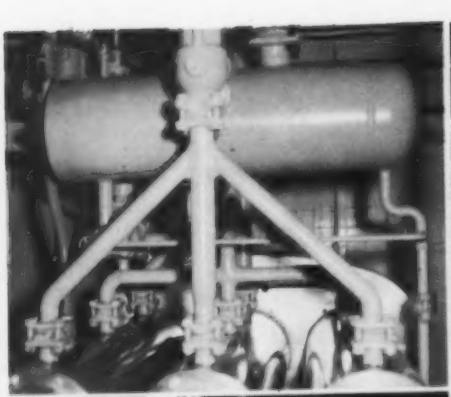
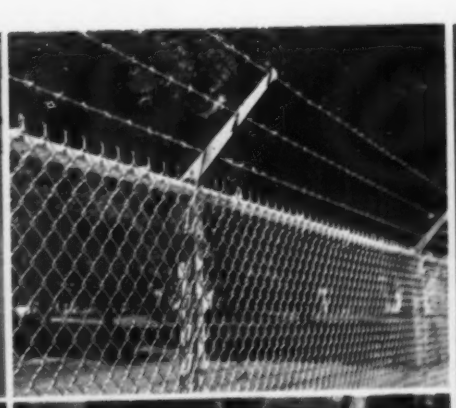
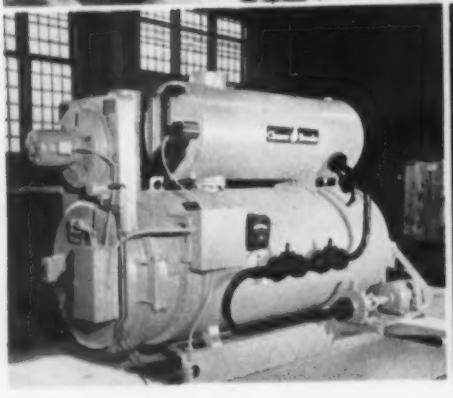
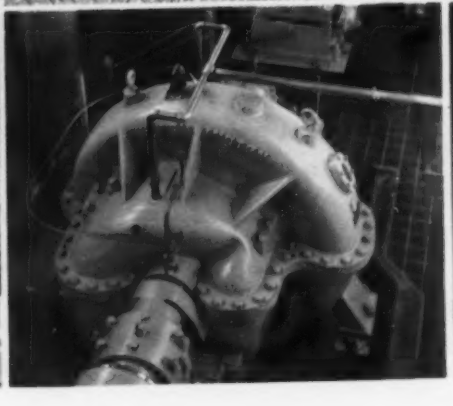


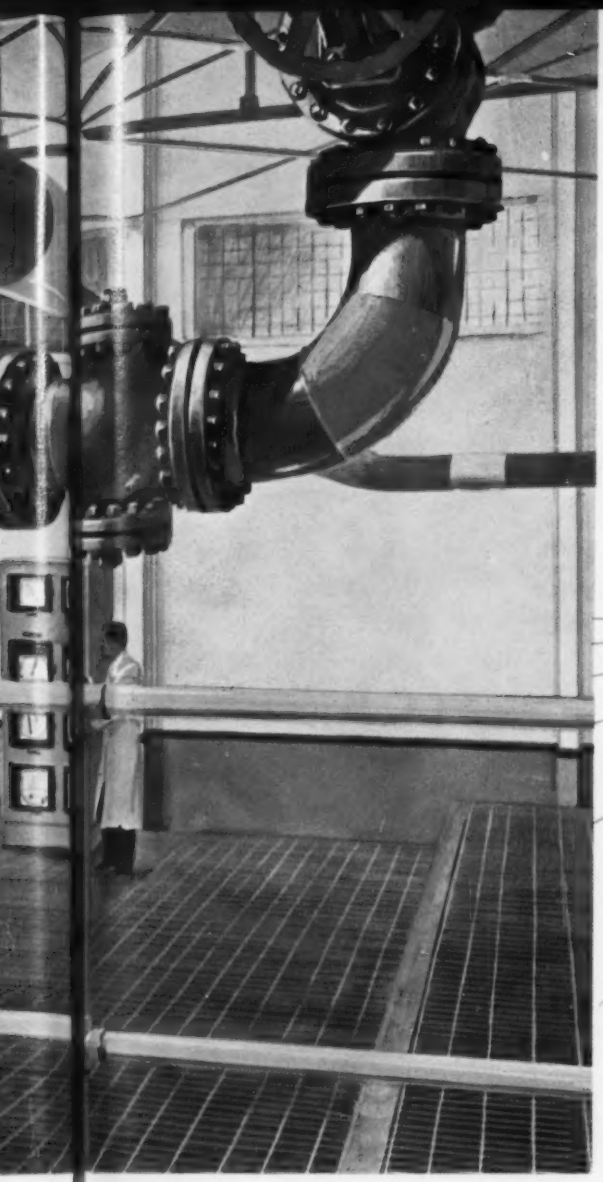




Ford







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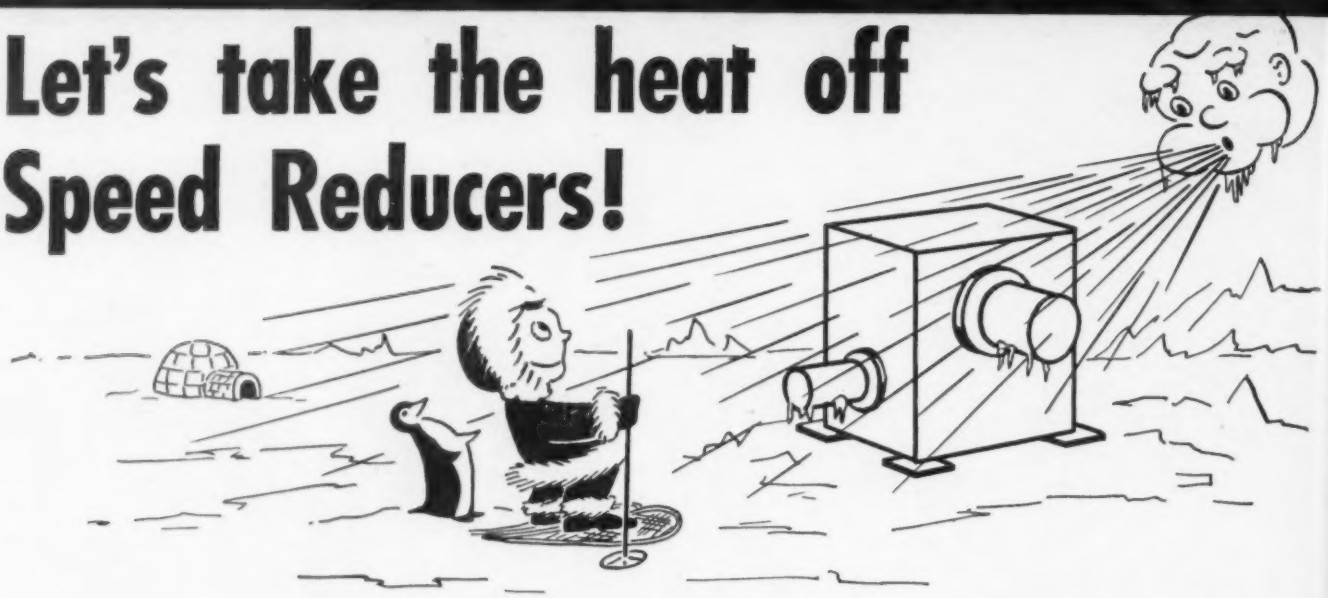
Let's take the heat off Speed Reducers!



A worm gear speed reducer is one of the toughest little customers in captivity. It reduces speeds day-in, day-out, with little complaint. While it works long and hard, it has limitations—set by ratio, center distance, RPM, mechanical and thermal HP ratings, etc. And, depending upon how precisely it was selected and fitted to the job requirements, it will do what it has to do.

But sometimes it's forced to play outside of its league. It must cope with job requirements that vary from here to there—normal 8 to 10 hour service without recurrent shock, the same length of service where there is some shock loading, continuous low-speed service and almost countless others. But the thing that really puts the pressure on reducers, the thing that's lurking in *every* set of job requirements—is h-e-a-t.

When you exceed the thermal capacity of a reducer for more than an hour or so, excessive temperature thins the lubricant resulting in wear; material, bearing and oil seal failures; etc. Of course, the proper lubricant will help but it can't cure the continuing problem of excessive heat.

So how can we lick this toughy? One way is to build the reducer housing oversize, big enough to radiate the heat away and keep temperatures down. But this type sticks out in aisles, louses up compact designs and barks shins. Then, we might try a smaller housing complete with fins on it to dissipate the heat. If this still doesn't work, another trick is to use a reducer with capacities and ratings a step above the ones we need. This is sending a man to do a boy's job. It's impractical, inefficient and costly. There *has* to be an easier, better, saner and cheaper way to do it. And there is!

In certain cases, where the size and type of reducer permits and where we can gain enough in thermal HP rating to keep heat generation in bounds, Cone-Drive Gears does it with fan-cooling.

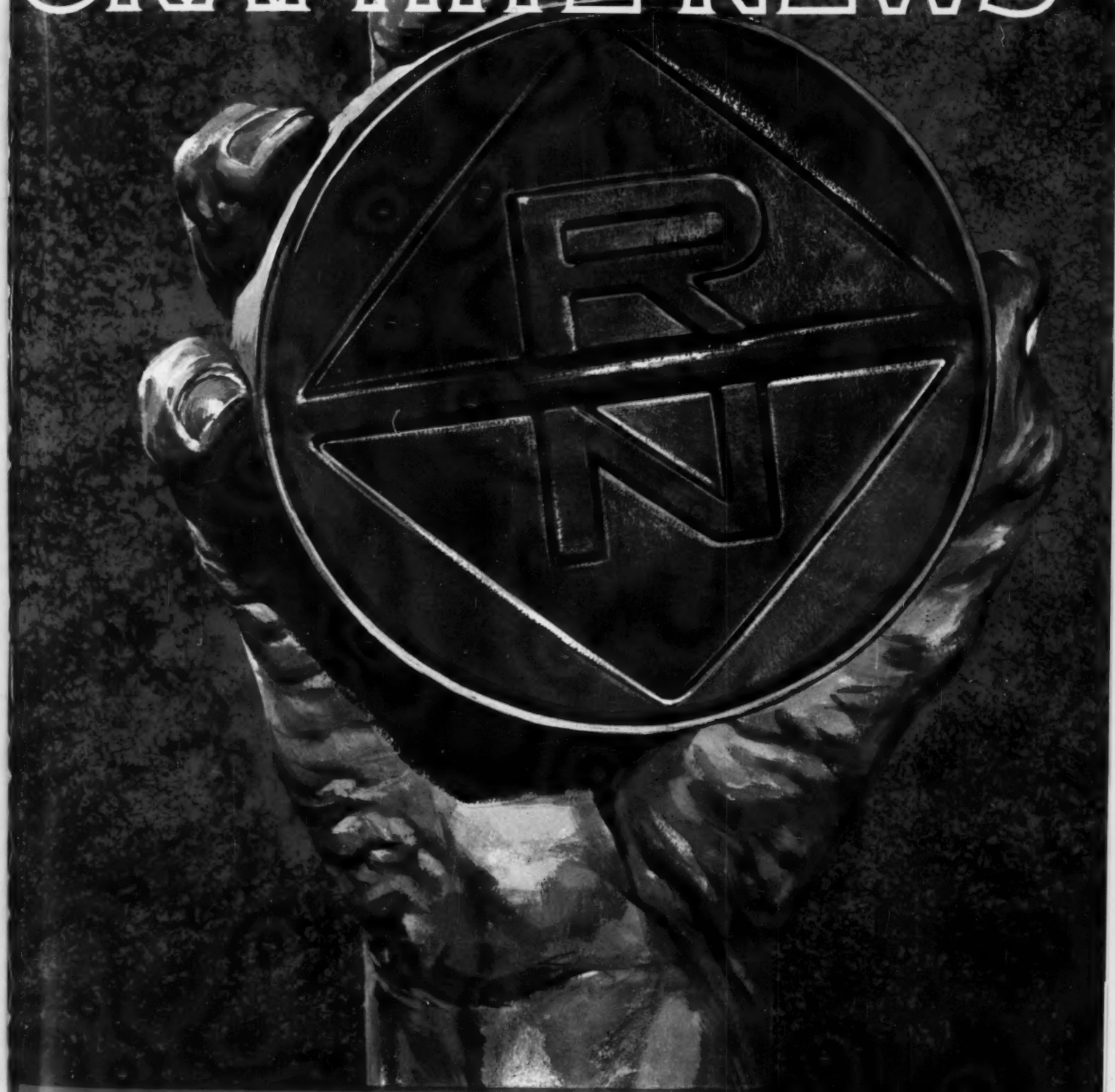
What's that? Simple. Just add a fan to the worm shaft plus the necessary air shields, fan cover, etc., and presto!—heat is no longer a problem. The air shields direct the fan-pushed air over the fins on the lower portion of the reducer. The fins are shaped and spotted to guide the air stream where it is needed. Thermal HP ratings are boosted tremendously, as high as 147% above those of standard reducers in some cases! Those over-worked, over-heated reducers will now do the job you bought them to do.

Other advantages? They're here in abundance. The size of the reducer stays the same. All parts on a Cone-Drive fan-cooled reducer are 100% interchangeable with parts for standard reducers. Oil capacity is identical. Shields are quickly removed without disconnecting the reducer. (This is important where severe operating conditions make periodic cleaning necessary). The reducer can also be operated *without* fan-cooling just by taking off the fan and shields.

This simple addition to standard Cone-Drive HU speed reducers might be just your answer—might save you some money. Write for Cone-Drive's Bulletin CD-218. It will tell you all about the full line of Cone-Drive double-enveloping worm gear reducers as well as the fan-cooled kind. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

CARBON COMPANY'S

CARBON AND GRAPHITE NEWS



R-N BRIQUETTES...an electric furnace charge material of uniform composition

By W. R. Weaver

R-N BRIQUETTES...an electric furnace charge material of uniform composition

W. R. WEAVER, Director,
Steel Conservation and Quality Control
Republic Steel Corporation

The need for a suitable charge material from direct reduction of iron ores – for both electric and open hearth furnaces – is more pressing today than it has been in the past several years. The R-N Process – a joint project of Republic Steel Corporation and National Lead Company – has to date produced a large quantity of briquettes which have undergone intensive testing. These briquettes offer electric furnace steelmakers the following advantages.

- **A charge material produced from either low or high grade ores.**
- **A charge material that is easy to handle and store.**
- **A charge material that can effectively replace up to 60% of ordinary heavy scrap grades.**
- **A charge material of uniform composition.**
- **A charge material with the stable cost of a manufactured product such as pig iron.**
- **A charge material low in deleterious impurities.**

Introduction

In the steel industry today, one of the surest paths to success with a new material is to provide a product that can be handled in less time and with less care than the material it replaces. R-N briquettes, with a bulk weight of 225 pounds per cubic foot and good strength, permit easy handling and storage because of very small space requirements. An equally favorable factor is that briquettes can be loaded easily into buckets or boxes for charging.

The R-N briquette – a product of directly reduced ore in the R-N Process – appears after numerous tests to be an efficient and effective charge material for the electric furnace. The product can be produced from either low or high grade ore, and offers many advantages as a replacement for up to 60% of ordinary heavy scrap grades in electric furnace operations.

Melters are provided with a charge material with both uniform density and electrical conductivity. This makes for improved operations because nonconducting spots are

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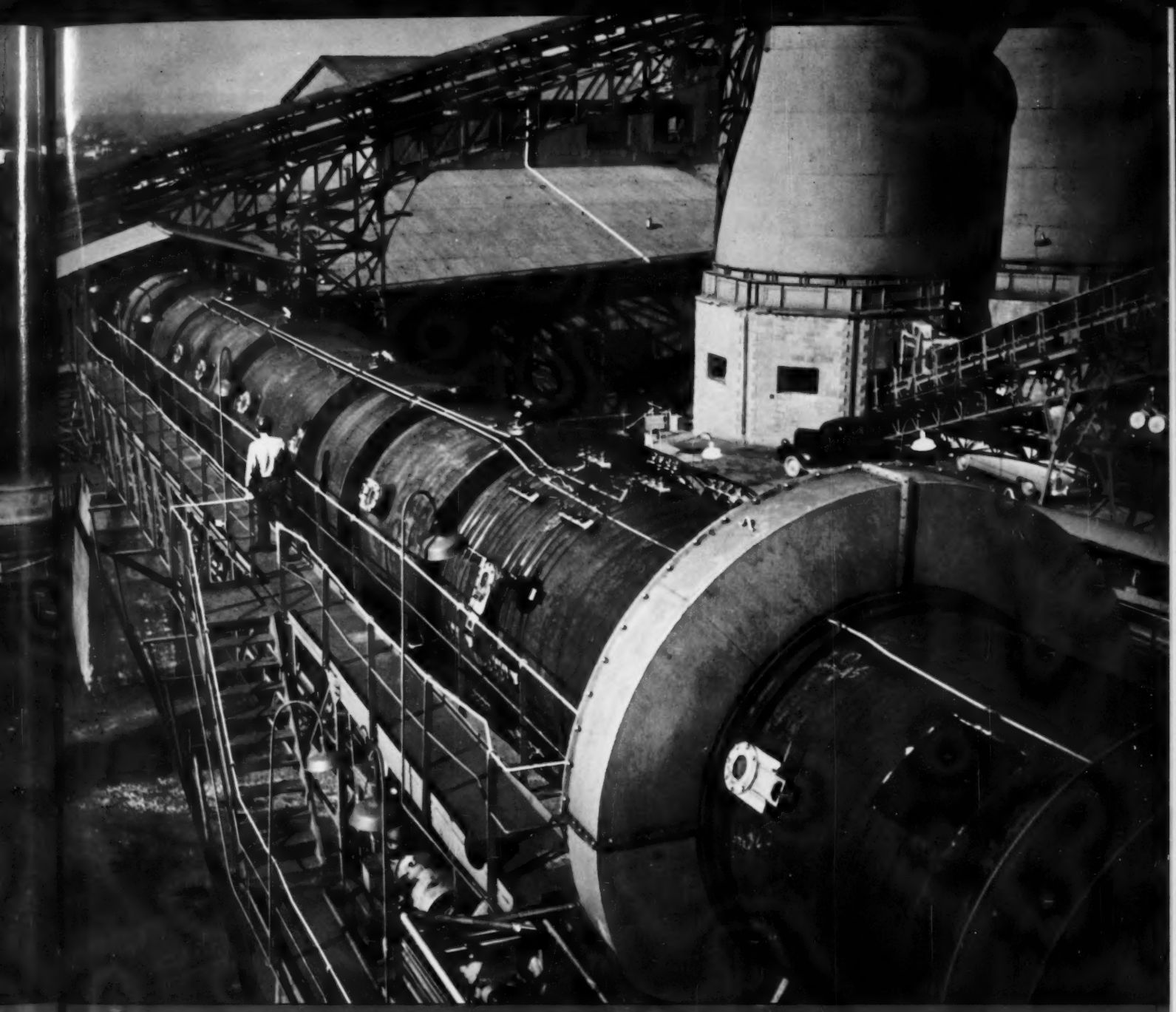

View of the rotary kiln at the Pilot Plant in Spaulding, Alabama.

eliminated from the charge—a very important factor where heavy power is employed for melt-down.

These briquettes are uniform as to composition and are free from harmful incidental alloying elements. This means melters can proceed with much more speed toward the completion of each phase of the melting operation. Freedom from dirt and contamination results in smaller slag volumes. Even where molten pig iron is used, slag volumes are a problem because of the presence of the slag-forming elements such as silicon and phosphorous.

In addition to uniformity of product, industry gains a charge material that will be uniform in price. The cost of producing R-N briquettes cannot be generalized because these figures are associated with a given location and with the treatment of a given type of raw material. However, the product that R-N briquettes offer the steelmaking industry is a charge material of uniform cost comparable to a manufactured product such as pig iron.

ADVERTISEMENT

R-N Briquettes Have Been Thoroughly Tested

To date, approximately 60,000 tons of briquettes have been produced at the Pilot Plant at Spaulding, Alabama. The material has been tested in substantial quantities in the blast furnace, in the open hearth, and in the electric furnace. This article covers testing procedures and results in Republic Steel Corporation's electric furnaces.

Two major melting tests (employing a total of approximately 3,385 tons of R-N briquettes) were conducted in Republic Steel Corporation's Chicago District electric furnaces. The first test was carried on in a 20′ shell – 85 ton, top-charge electric furnace from February 18, to April 14, 1957. The second test was conducted in a 22′ shell – 135 ton, top-charge electric furnace from September 18, to October 10, 1958. In both instances, R-N briquettes were utilized as a straight replacement for scrap with no pig iron being employed.

Melting Test Number One

A total of 2,064 net tons of briquettes produced from Port Henry concentrates were shipped to Republic Steel Corporation's Chicago District for melting tests in an electric furnace. The instructions to the melt shop were "to examine the melting characteristics of R-N briquettes as a straight replacement for scrap in an electric furnace." A number of heats were made using varying percentages of R-N briquettes. The results of these heats were compared to those from companion heats in which no R-N was charged to determine the differences in the melting performance as the percentage of scrap replacement by R-N briquettes in the charge was increased from 20%, through 30%, 40% and 50%, up to 60%. It should be stressed that the data presented here are centered on the 40% level, which was the level decided upon by operating supervision as the one most desirable for the accumulation of data.

The briquettes used were 3¾″ diameter round slugs, 3″ to 4″ thick, weighing from six to seven pounds each. The top and bottom surfaces were flat and parallel, creating a strong tendency to nest or stack inside the electric furnace.

TABLE I

R-N Melting Test Number One

All Cold Charge — 40% R-N — 20′ Shell — 85-Ton — Top-Charge Furnace

Summary of Operating Data

Per Heat — Averages of 13 Heats	Control Heats	R-N Heats
Materials Charged — Pounds		
No. 1 Heavy Melt	186,000	113,600
R-N Briquettes	—	72,600
Total Scrap	186,000	186,200
Carbon	738	2,269
Power — K.W.H. Per Ton		
Charge to Melt	484	531
Charge to Tap	525	576
Times — Hours		
Adjusted (Less Delays)		
Charge to Melt	3.84	3.95
Charge to Tap	4.86	4.94
Patching Time	24	21
Tons Per Hour (Total Tapped)		
Charge to Tap — Actual	17.8	17.1
Tap to Tap — Actual	16.0	15.4
(Less Delays)		
Charge to Tap	19.00	18.33
Yields — %		
Gross Product Yield	94.13	93.33
Pounds Per Ton — Total Tapped		
Feed Ore	80.5	58.8
Burnt Lime	80.0	91.1
Chemistry — Steel		
Carbon at Melt	0.26	0.29
Carbon Drop — Melt to Tap	0.10	0.06
Manganese at Tap	0.19	0.14
Final:		
Phosphorous	.010	.012
Sulphur	.032	.030
Total Incidental Alloys	.38	.32
Slag:		
At Tap: FeO	22.29	23.61
TiO_2	0.57	2.61

Data from the first test are shown in Table I. In general, the R-N briquettes were observed to perform very similarly to regular heavy melting scrap such as crops or bloom butts. The advantages and liabilities due to the chemical and physical nature of the R-N product are shown in Table II.

Heat Time (charge to melt or charge to tap)	Stand-off
Bottom Repair Time	Stand-off
Power Consumption	Slight increase
Carbon required in charge	Slight increase
Ore Consumption	Saving
Metallurgical yield	Stand-off
Melt-in phosphorous	Advantage
Melt-in sulphur	Advantage
Total residual tramp alloys	Advantage

Table II. Advantages and liabilities of R-N material due to chemical and physical nature of the product.

Lower than normal yields were expected for two reasons. First, clean electric furnace melting scrap is generally conceded to be about 98% Fe, whereas the R-N material used averaged 95.30% Fe when unloaded into stock. Second, the R-N heats were under-charged deliberately to prevent any spillage that might occur due to the gentle boiling action caused by iron oxides present in the R-N material. The briquettes contained 8.3% of the iron as oxides in their various forms. In spite of this, the slags produced were not very different from those of the all-scrap heats and the bath boiling action produced a desired circulation of the metal. A point of interest to melters and furnace operators is that such action is favorable to the development of uniform temperature throughout the bath and speeds up removal of carbon.

The iron oxides contained in the R-N briquettes provided self-oreing characteristics. This meant that when R-N product was used as a charge material to replace scrap, if all other factors were maintained in balance, lower melt-in carbons would result. It was necessary, therefore, to charge supplemental carbon in the R-N heats. Broken electrodes were used for this purpose.

The pounds of ore consumed per net ton of steel tapped are consistently lower on the R-N than on the comparison heats. In spite of this, as noted above, melt-in carbons are generally lower.

It has been assumed that regularly established shop practices produced satisfactory melt-in carbons. For the R-N heats to be melted at carbon levels equivalent to the regular heats, even less ore than actually used would have been required.

Table I shows that heats made with R-N briquettes produced lower values for sulphur and total residual alloys than did regular scrap heats. These reduced levels are a definite advantage for the R-N heats over the regular scrap heats.

A car being loaded with R-N briquettes for shipment to Republic Steel Corporation's Chicago District for melting tests in an electric furnace.

Melting Test Number Two

To supplement and substantiate the data obtained during the first tests, a second series of test heats was scheduled during September and October of 1958.

Because of shop operating conditions, one important factor had to be modified in the second test. Since the time of the first test, three electric furnaces had been enlarged from 85-ton to 135-ton rated capacity. Only the latter furnaces were available at the time of the second test. This difference in furnace capacity in the two tests must be kept in mind.

A total of 1321 net tons of R-N briquettes produced from Port Henry concentrate were melted in twenty heats producing 3,030 net tons of ingots. The material was similar chemically to that used in the first test, but the physical shape of the briquettes had been modified. The top face of these briquettes was curved and hence the top and bottom faces were no longer parallel. A minimum tendency toward nesting and stacking inside the furnace was observed as a result of this physical shape modification.

The entire test pattern was designed to improve quality of the data obtained over that of the first test. Particular stress was applied on yield and power consumption data. All the metal tapped was weighed and ingots were weighed individually on a specially installed scale. Skulls, spills and even pit scrap were weighed. Short ingots or butts were measured. Specially designed power monitoring and data logging equipment was installed to provide a reading every minute on the power consumed by each individual electrode. Meters were carefully calibrated and presented readings within an accuracy of 1%. A special observer supervised the weighing of all materials, both charged and produced. A second observer was assigned to the power monitoring equipment, and an experienced metallurgical observer covered and logged all details of the furnace operations. All of these activities were supervised on a twenty-four hour basis.

Heats were made in "blocks" of five heats each. An equivalent number of regular or "control" heats were made. The test blocks of five heats each were alternated between R-N and control heats to insure balancing and randomizing the test conditions and to avoid bias which might otherwise result. This "design of experiment" afforded subsequent analysis of the accruing data on a sound statistical basis and the resultant formulation of conclusions and interpretations with specific degrees of confidence.

A summary of operating data appears in Table III.

TABLE III

R-N Melting Test Number Two

All Cold Charge — 40% R-N — 22' Shell — 135-Ton — Top-Charge Furnace

Summary of Operating Data

Per Heat — Averages of 20 Heats	Control Heats	R-N Heats
Charge Materials — Pounds		
Heavy Bloom Crops	119,730	—
Other Scrap	186,370	190,545
R-N Briquettes	—	119,486
Total Scrap	306,100	310,031
Burnt Lime	5,565	8,395
Carbon	1,020	3,335
Feed Materials		
Liberian Ore	3,950	4,528
Burnt Lime	3,562	2,205
Total Weight Melted	320,197	328,494
Total Metallics	314,708	318,813
Power — K.W.H. per Ton:		
Good Ingots Only	478	505
To Melt Total Charge	383	419
Total Weight Tapped	448	485
Times — Actual — Hours		
Charge to All Melted	4.50	4.73
Charge to Tap	5.90	6.04
Tap to Tap	6.51	6.50
Fettling Time	0.46	0.43
Adjusted (Less Delays)		
Charge to All Melted	3.94	4.21
Charge to Tap	5.34	5.50
Net Time Power To Furnace:		
Power on to All Melted	3.52	3.74
Power on to Tap	4.71	4.77
Product — Pounds		
Good Ingots Only	284,575	290,753
Total Metal Tapped	302,626	303,040
Pounds Per Ton — Total Tapped		
Feed Ore	28.84	30.46
Burnt Lime	60.29	68.72
Carbon	6.74	21.98
Yields		
Good Ingots Only	90.49	91.20
Gross Product Yield	96.20	95.05
Tons Per Hour (Total Tapped)		
Actual: Charge to Tap	26.03	25.30
Tap to Tap	23.60	23.45
Net: (Less Delays)		
Charge to Tap	28.53	27.72
Chemistry — Steel %		
Carbon at Melt	0.466	0.494
Manganese at Tap	.296	.194
Carbon Drop — Melt to Tap	.133	.174
Final:		
Carbon	.437	.442
Manganese	1.119	1.099
Phosphorous	.0161	.016
Sulphur	.0353	.030
Total Incidental Alloys	.339	.262
Slag:		
At Melt: FeO	17.87	15.01
At Tap: FeO	17.31	18.43
CaO	41.48	45.99
MgO	6.65	5.78
SiO_2	16.26	14.56
Al_2O_3	3.95	4.13
P_2O_5	.65	.69
V-Ratio	2.496	2.859

All heats, both control and R-N, were produced under the 100% scrap practice; no pig iron, either hot or cold, was employed.

On all control heats, 40% of the total scrap charged was composed of clean bloom butts or heavy crops. On the R-N heats this class of scrap was replaced with an equal amount of R-N briquettes, thus affording a direct replacement of a specific and stable scrap of known quantity. All heats comprising the test were melted for the same grade of steel and poured in the same size molds.

The results of the second test fortify and validate the conclusions drawn from the initial test. The magnitude of many factors was at a different level than in the original run due to the larger size furnace used and to the greater precision obtained in product weights. When the R-N heats are compared to the control heats, all criteria studied will be found to be in the same "direction" and by roughly the same relative order of magnitude as in the initial test run.

R-N as Straight Scrap Replacement

The data from both tests indicate that in electric furnace operations using an all scrap charge, R-N briquettes are a thoroughly satisfactory substitute for ordinary grades of heavy melting scrap, up to 60% of the scrap charge.

No difficulties were experienced in furnace operation. Heats appeared normal in all respects. A little more power was required to melt the total balanced R-N charge than to melt the scrap charge which it replaced. Most heats required more than the customary amounts of burnt lime. Feed ore consumption was entirely a function of the melt-in and required tapping carbons. The iron oxide content of the R-N product produced noticeably more active bath conditions which is a desired feature. There was no discernible difference in product quality by comparison to shop standards.

Summary of Tests One and Two

Heat Time

Actual times experienced for charge to melt, charge to tap and tap to tap respectively are provided for information purposes only since these are not considered appropriate measures of comparison.

Since there are rather frequent delays on almost all heats which are not necessarily of an unusual nature, but are certainly extraneous to the "normal" melting of a heat and in no way related to the materials themselves, it is appropriate to remove such recorded delays, thus providing a set of *adjusted* or net times. These are shown in Table IV.

	1st Test Run 85-Ton Furnace	2nd Test Run 135-Ton Furnace
Charge to Melt		
Control	3.84	3.94
R-N	3.95	4.21
Charge to Tap		
Control	4.86	5.34
R-N	4.94	5.50

Table IV — Adjusted Heat Times in Hours — Delays removed

R-N heats were slightly longer on the average than control heats, with respect to both charge to melt and charge to tap times. However, it is significant to note that the penalty is small in magnitude.

Tons Per Hour

If produced tonnages are equivalent, a small penalty in tons per hour would result from slightly longer heat times. Since there are always many factors determining what portion of the total metal coming out of the furnace results in good ingots, *total tons tapped* is a more appropriate measure than "good ingots" for a comparison of raw materials. R-N heats produced about the same total product as did the control heats. There is a small tons per hour difference, but it is not statistically significant. This is shown in Table V.

	1st Test Run 85-Ton Furnace	2nd Test Run 135-Ton Furnace
Control Heats	19.00	28.53
R-N Heats	18.33	27.72

Table V — Tons Per Hour — Total Metal Tapped — Adjusted Heat Times

Power Consumption

As was found in the first test run, the R-N heats required somewhat more power than did the control heats. The comparison based on K.W.H. per ton of total metal tapped is shown in Table VI.

	1st Test Run 85-Ton Furnace	2nd Test Run 135-Ton Furnace
Control Heats	525	448
R-N Heats	576	485

Table VI — K.W.H. per ton of Total Metal Tapped

Yields

A comparison of good ingot yields is not considered as meaningful a comparison as the gross product yield. The latter includes ingots, butts, skulls and pit scrap — all the metal produced from the materials used and which came out of the furnace. These figures are compared in Table VII.

	1st Test Run 85-Ton Furnace	2nd Test Run 135-Ton Furnace
Control Heats	94.13	96.20
R-N Heats	93.33	95.05

Table VII — Gross Product — Total Metal Tapped as % of Total Metallics

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The heavy bloom butts which the R-N briquettes replaced can be safely assumed to be 98.0% Fe. The R-N material melted averaged 95.30% Fe, a difference of 2.70%. On a 40% R-N replacement basis, *the R-N heats could be expected to produce 2.70% x 40% or 1.08% lower yields than the control heats.* Thus, there is some evidence of the possibility of a *slight* actual yield liability, over and above the difference in the iron content of the two materials.

Burnt Lime—Feed Ore—Carbon

The additional burnt lime consumed by the R-N heats in the amount of 8.43 pounds per ton tapped is indicated to be a significant difference. However, the fact that more burnt lime was *used* does not necessarily mean that more was *required.* The difference is statistically significant, but could be merely a reflection of how the heats were worked. Slag iron oxides (FeO) were higher on the R-N heats at tap, although they were lower at melt. This fact offers some evidence that the additional lime may have been needed, or at least provides the probable reason for such action by the melting crew. The objective was to charge sufficient additional carbon in the R-N heats to produce melt-in carbons equivalent to the control heats. Since the melt-in carbons were substantially the same, and since all heats were tapped for the same grade of steel, the carbon drop melt to tap would be substantially equivalent. This means the use of feed ore would be approximately the same. Actually, there was a small excess for the R-N heats, but not a significant amount, especially since the R-N heats actually experienced a four-point greater carbon drop from melt to tap.

Significant Items of Steel Analysis

Results show the phosphorous content of both control and R-N heats to be approximately the same. R-N heats had lower sulphur by five points, .030% compared to .035%. Total of incidental alloys (copper, nickel, chromium and molybdenum) was also substantially lower in the R-N heats, 0.262% compared to 0.339%.

Metallurgical Factors

Metallurgical examination disclosed no discernible differences in quality with respect to grain size, cleanliness soundness, etc. Blooming Mill observation *produced definitely better ratings on surface quality during rolling on the R-N heats. This advantage is ascribed to the five point lower sulphur in a range which is rather critical surface wise.*

Conclusions

The R-N briquette may be looked upon as a competitor of scrap and, in a way, it is. But in other ways it is not. Scrap is a by-product, the value of which fluctuates widely on a supply and demand basis. Likewise, its quality fluctuates widely and it may contain harmful residual elements. R-N briquettes, on the other hand, show the stable cost patterns associated with a manufactured product such as pig iron. The product is easier to handle, store and charge, and also offers the melter a charge material of uniform composition. For these reasons, the use of R-N briquettes to displace scrap, will undoubtedly prove more efficient and have a stabilizing effect on the price of scrap. This is sure to relieve steelmakers of the dangers resulting from excessive fluctuations in the price of scrap.

It is wrong, however, to look at high grade R-N briquettes as being just a competitor of scrap. Where a new installation is considered, there are indications that the combination of an R-N plant with electric furnaces would in many cases be more economic to operate and would involve less investment costs than a blast furnace-open hearth combination. Under such circumstances the R-N briquettes would be competing both with scrap and pig iron. A detailed discussion of the economics of this situation is beyond the scope of this article; it will suffice to say that it is believed the R-N Process can compete favorably under these circumstances.

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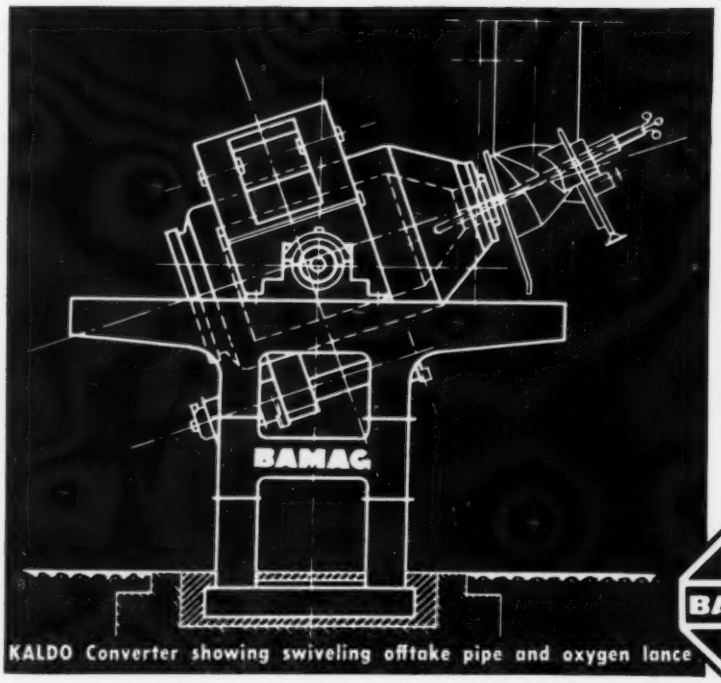

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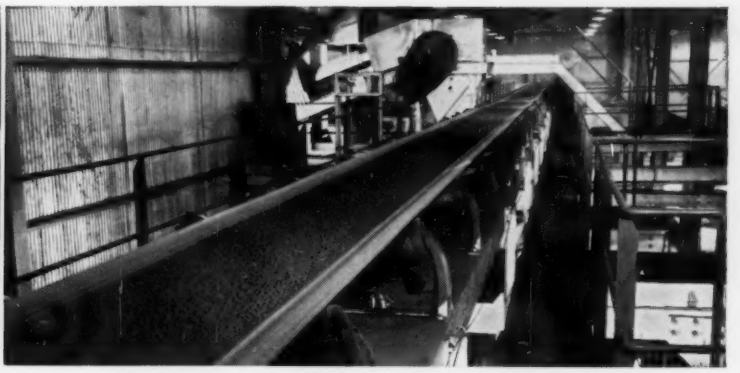
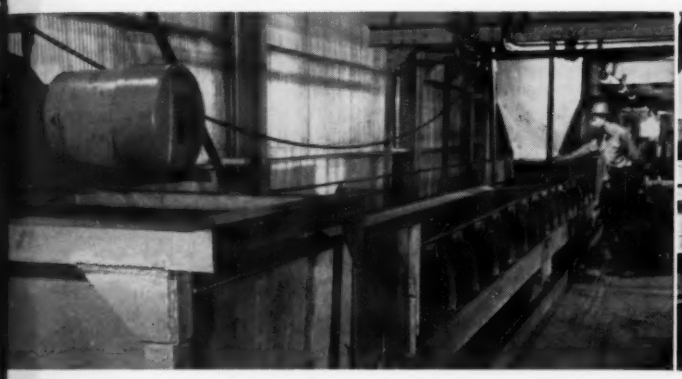
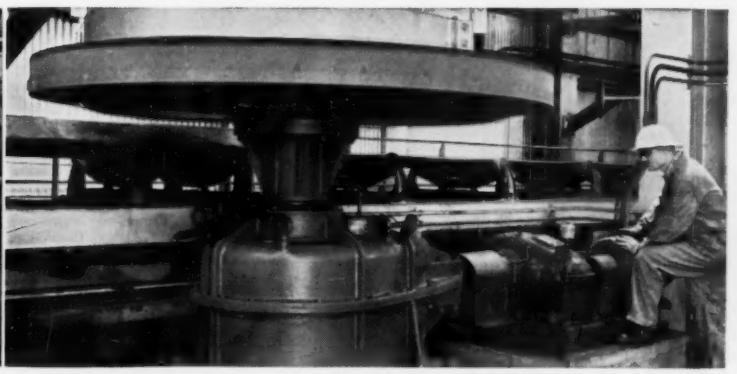
UNLOADING — This Link-Belt car shaker assures rapid and economical unloading of raw materials from hopper bottom cars to track hoppers at yard level.



TRANSPORTATION — 30-inch wide Link-Belt belt conveyor takes ore fines for a 294-foot ride to a Link-Belt shuttle conveyor serving three storage bins.



DISTRIBUTION — Two Link-Belt shuttle conveyors deliver raw materials—coke, flue dust, lime, ore fines or sinter fines—to seven storage bins prior to processing operations.



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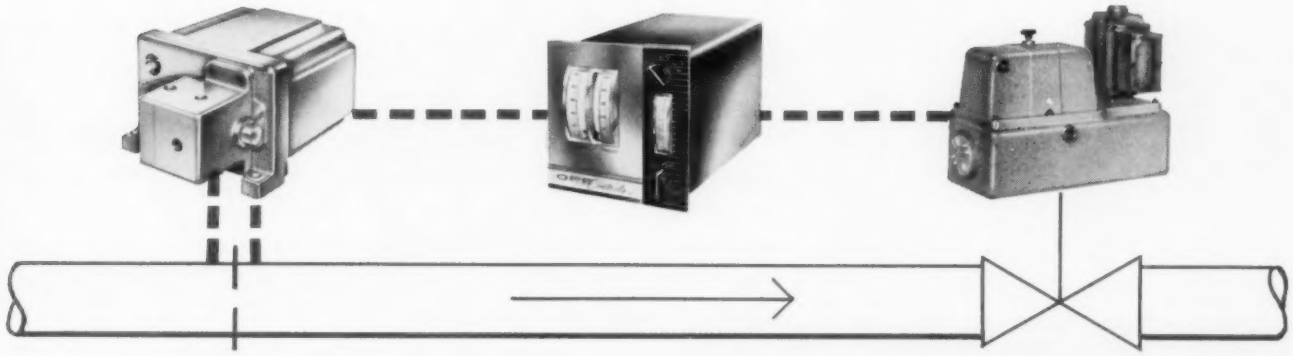

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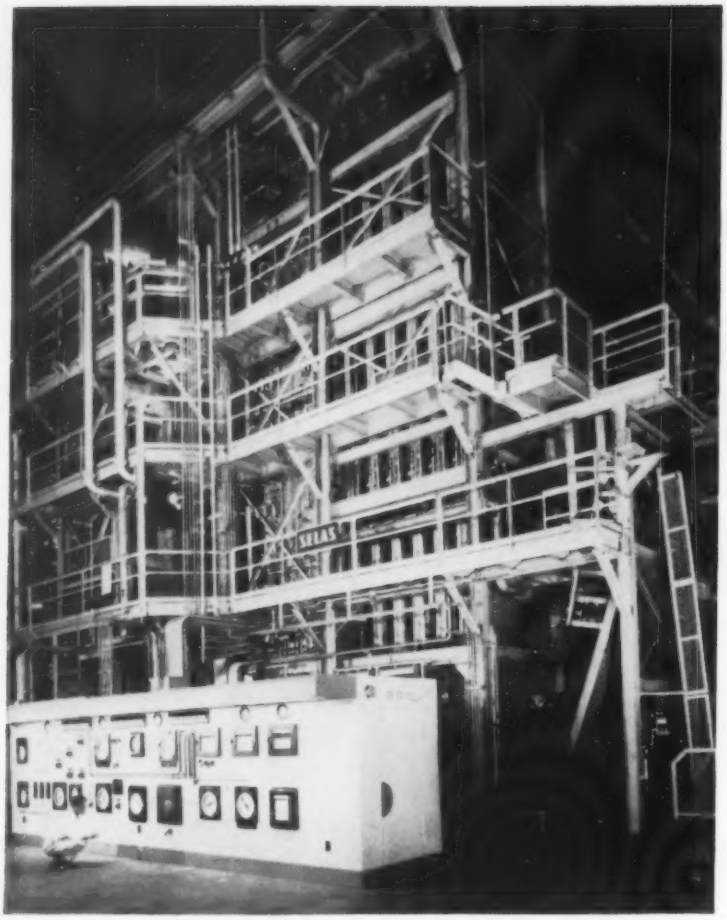

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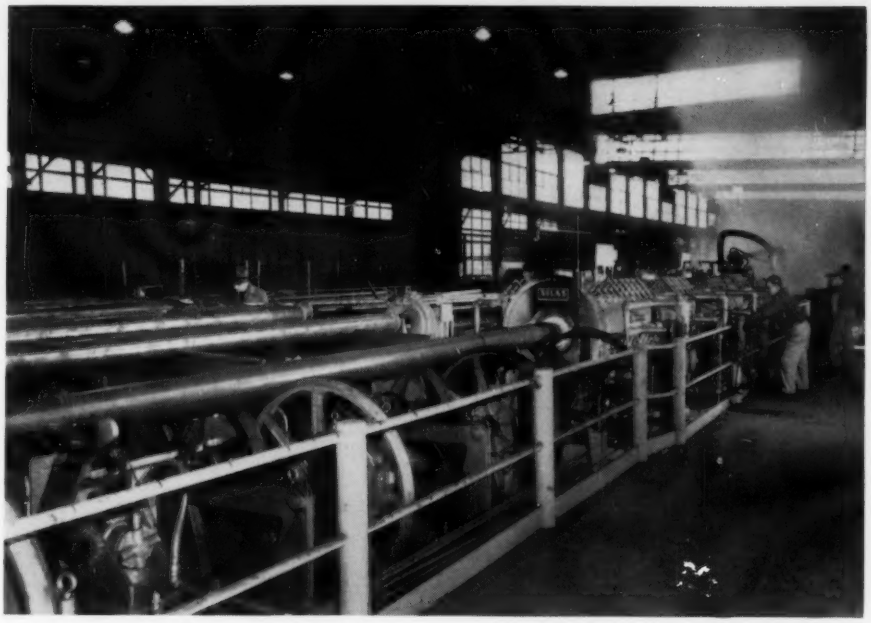

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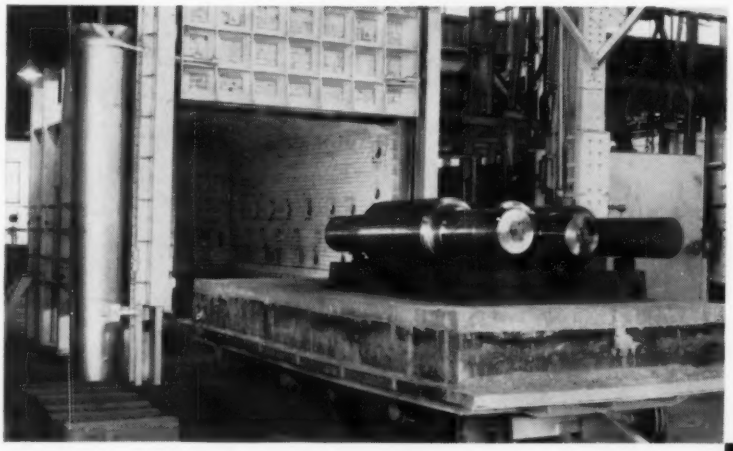

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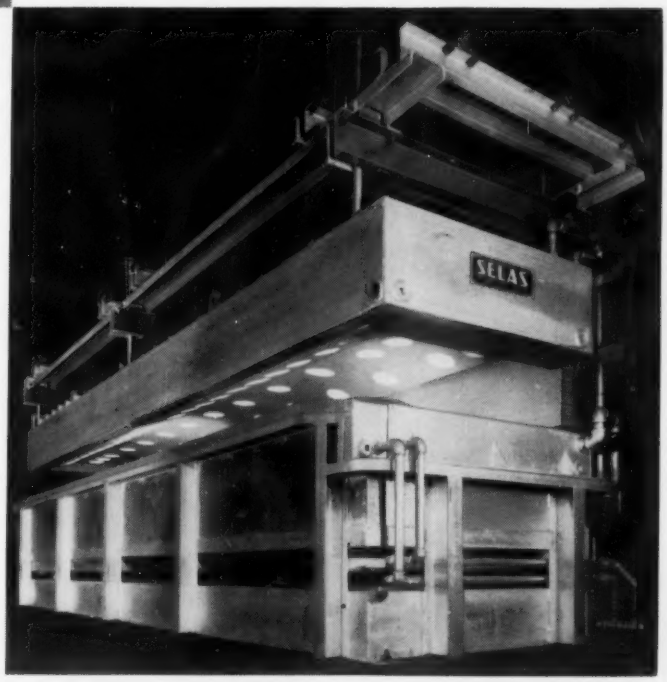

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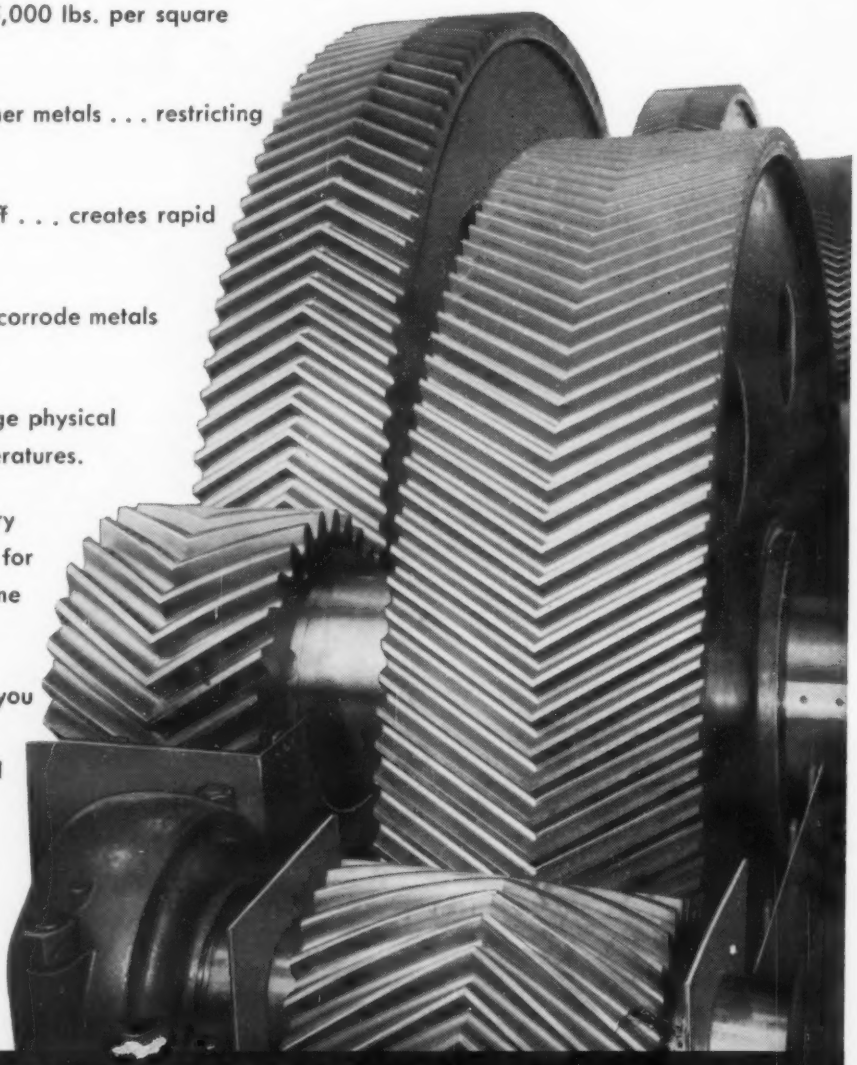

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METALGRAMS

UNION CARBIDE METALS

. . . news about "Electromet" ferroalloys and metals

APRIL, 1960

OPEN-HEARTH SAVINGS -- Economics are changing the form in which chromium is added to 4100 and 5100 series constructional steels. Melters are switching to furnace additions of new blocking chrome. Reason: Savings of $1.65 to $2.50 per ton in chromium and silicon costs. The alloy replaces exothermic ferrochrome ladle additions and provides all the silicon needed for blocking. Your Union Carbide Metals representative will be glad to give you additional information.

* * *

FASTEST-DISSOLVING FERROCHROME -- Stainless steel melters continue to be impressed with the rapid solubility of the new "Simplex" low-carbon ferrochrome. In a typical test, 3,300 lbs. of the alloy (7.7 per cent chromium added) dissolved in a 15-ton heat after refurnacing in less than 25 minutes. In addition, 500 lbs. of "Simplex" ferrochrome added to the ladle during refurnacing dissolved before the ladle was half full. Get further information in a new six-page folder, F-20,118.

* * *

COLORS AID IDENTIFICATION -- Bags of 50 per cent ferrosilicon, standard and medium-carbon ferromanganese, and calcium-silicon are now color-coded for fast identification. Melters report 10 to 15 per cent higher recoveries with bagged alloys in the ladle, cutting alloy costs. In addition, bags give closer control over specifications, cut handling losses, and aid inventory control. Union Carbide Metals produces 11 alloys in bags. For folder and chart showing bag specifications and colors, write for F-20,121.

* * *

QUALITY IN QUANTITY -- Each of the more than 100 "Electromet" ferroalloys and metals is carefully inspected during every step of production. The aim: To make sure that each alloy meets close chemical specifications consistently. Samples are taken during raw material preparation, furnacing, cleaning and crushing, packing, storage, and shipping. During an average month at Union Carbide Metals' Marietta, Ohio, plant, more than 30,000 tests are made on over 10,000 samples. For further details, ask for the Summer 1959 issue of UNION CARBIDE METALS REVIEW.

* * *

SAVINGS GROW WITH FERROMANGANESE-SILICON -- Several stainless melters have reported that using ferromanganese-silicon for slag reduction has increased the recovery of chromium from the slag. A drop of as much as 4 per cent in the chromium oxide content of the slag has been reported. To a melter charging 12 per cent chromium, a one per cent chromium recovery means a saving of 2.4 lbs. of chromium per ton as low-carbon ferrochrome, worth about 75 cents per ton. These savings are in addition to those previously reported -- $4 to $9 per ton for 200 series stainless and $0.75 to $1.75 per ton for 300 grades. Further facts are in a four-page folder, F-20,093.

* * *

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

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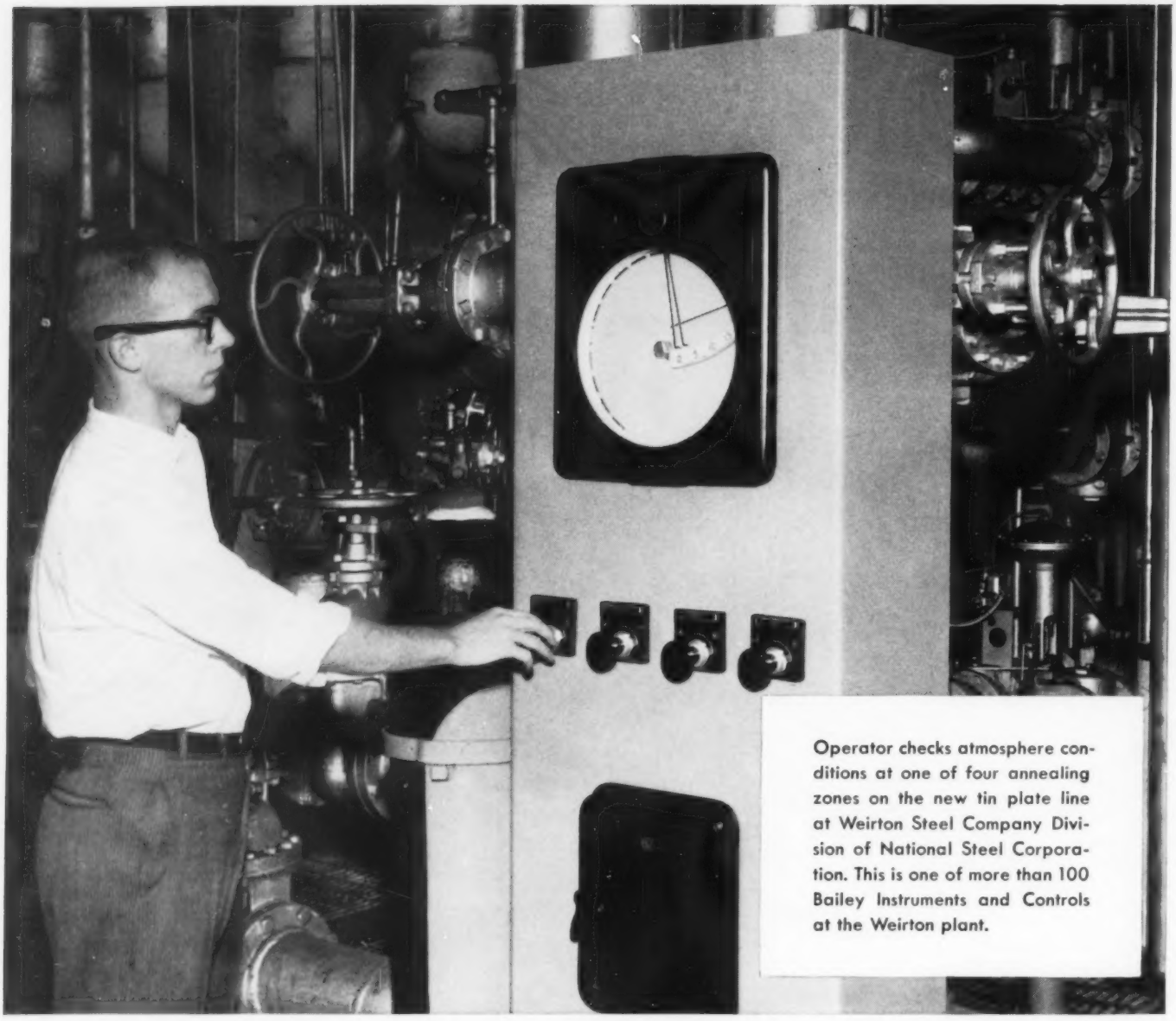

Operator checks atmosphere conditions at one of four annealing zones on the new tin plate line at Weirton Steel Company Division of National Steel Corporation. This is one of more than 100 Bailey Instruments and Controls at the Weirton plant.

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S113-1

IRON AND STEEL DIVISION

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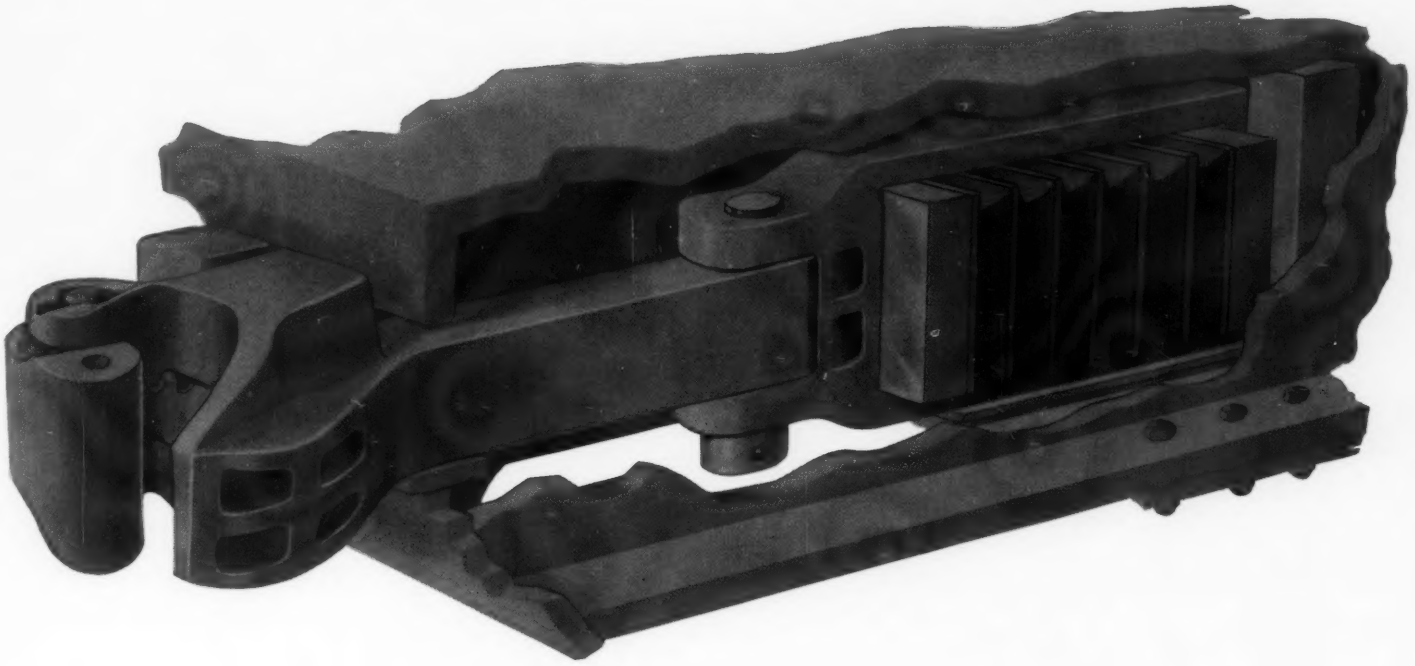

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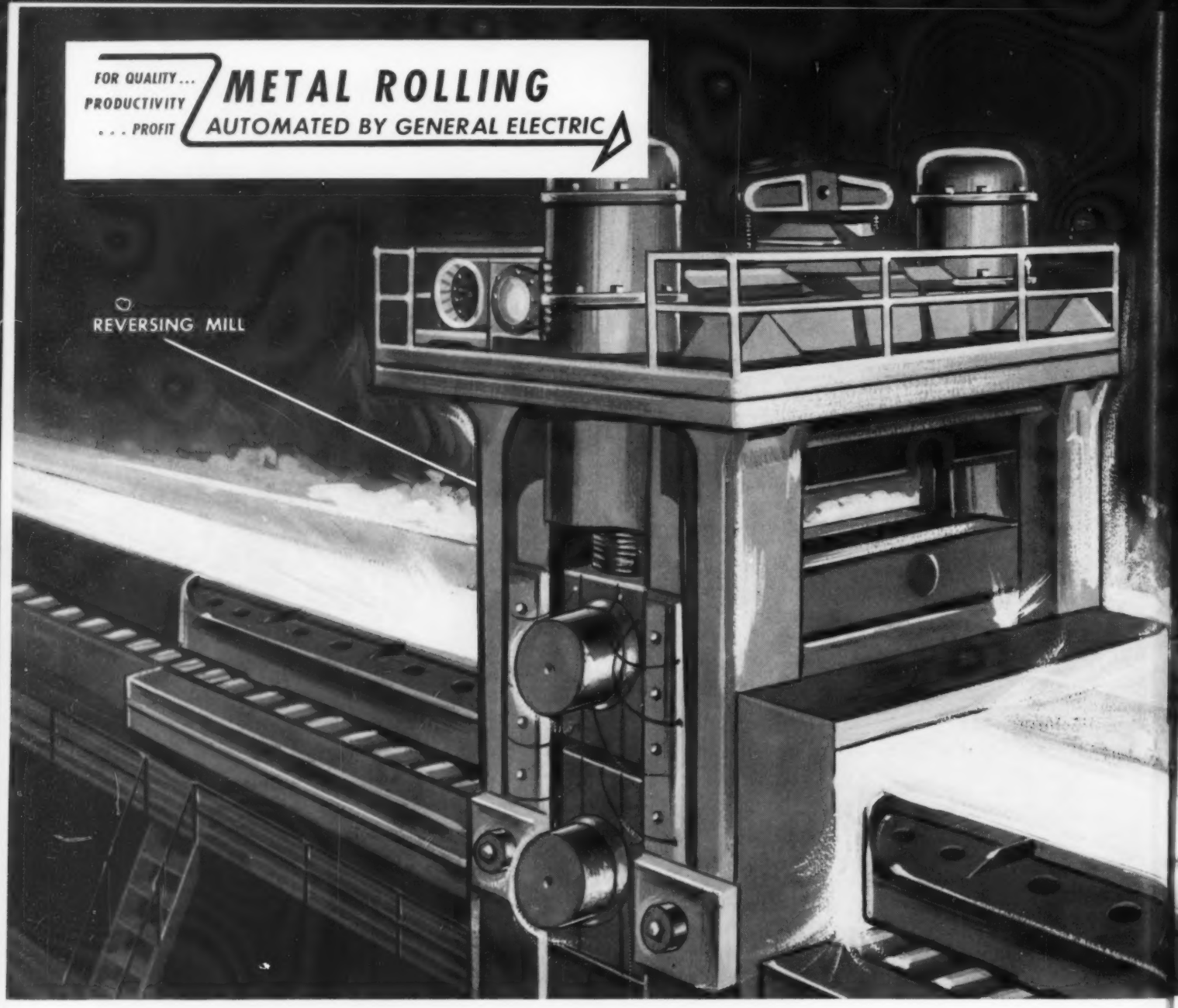


A NEW CONTROL FOR REVERSING HOT MILLS

G-E program-control system operates

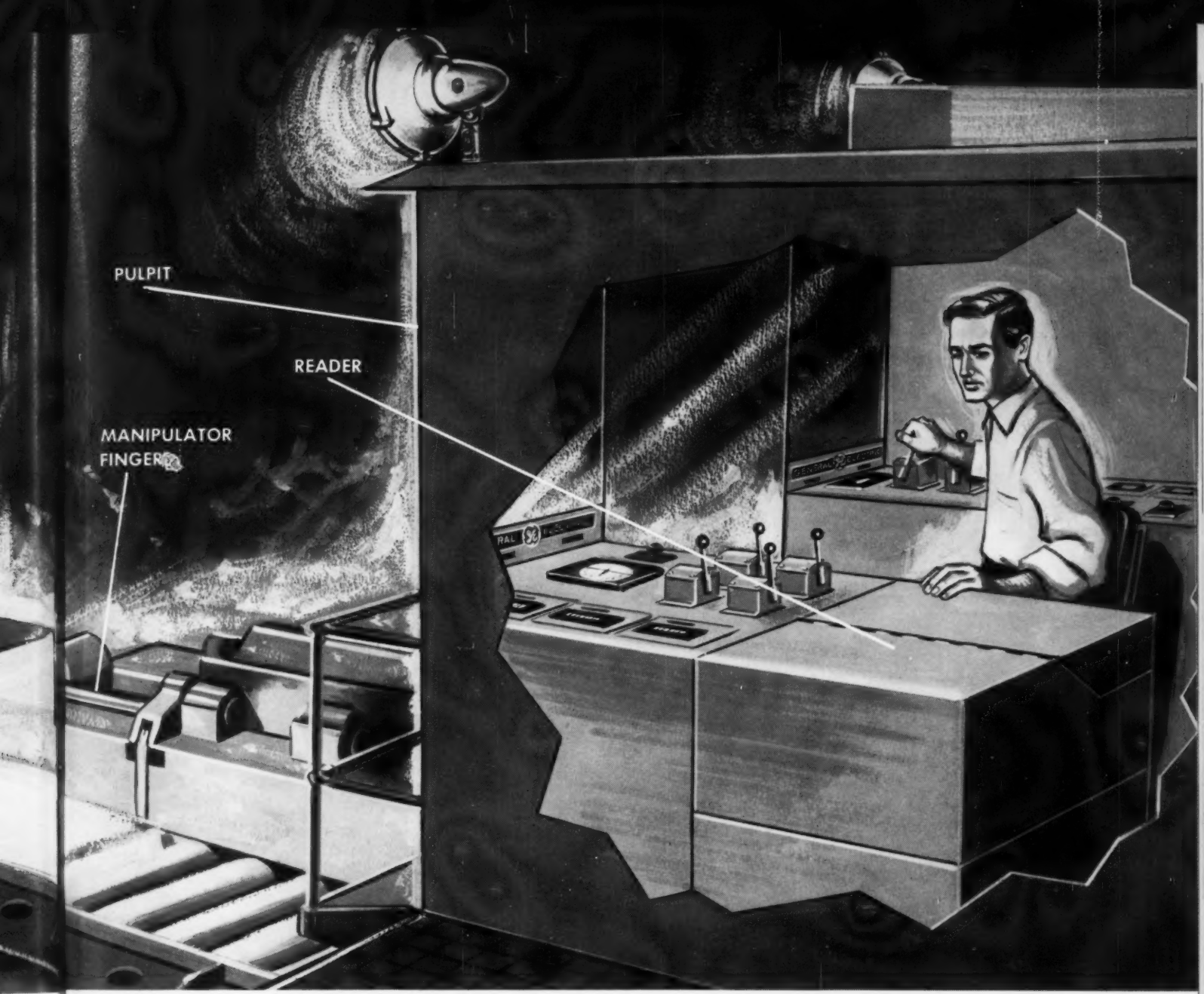
General Electric's new program control for reversing hot mills performs an entire rolling cycle—automatically. Increased yield per ingot, substantially improved product quality and reduced unit cost are outstanding advantages of this new control system.

HOW G-E PROGRAM CONTROL OPERATES

The entire rolling operation, from ingot entry to finished slab, is controlled automatically. A punched card or other memory device is used for data storage and to control the entire operating sequence.

The cards are punched to perform mill functions previously determined to be the most efficient for the equipment involved and the product desired. This controlling element is read by an industrial card reader, which sends impulses to the control circuit and on to the screwdown motors, mill table drives, and manipulator drives. The operator, seated in the pulpit, inserts the card into the reader, depresses a pushbutton, and then the control directs the entire operating sequence. The speed of the mill table, position of the rolls, manipulation of the piece, and sequencing operations for all passes are controlled automatically by the program control system.

Yield is increased—The General Electric program control schedules the mill tables to run at the most desirable and efficient speed. It also brings the rolls into the position calculated for maximum ingot reduction on each pass and turns the ingot at the exact time determined to produce highest slab quality. This precision control produces more finished slabs per turn than manually controlled mills.



entire rolling cycle — automatically

Quality is improved—Greater slab uniformity is obtained with G-E automatic program control. Consistent roll settings and mill speeds produce uniform slabs. This improved quality control also results in substantially less scrap.

Unit cost is reduced—Automatic programming produces finished slabs faster than ever before possible. Higher operating efficiency of machinery and faster equipment adjustment by automatic control cut production time—therein reducing unit cost.

Get all the facts on this new automatic control for steel mills. Contact your G-E Apparatus Sales Engineer today, or write to Sect. 785–10, General Electric Company, Schenectady 5, N. Y., for bulletin GEA-6869. Industry Control Department, Salem, Virginia.

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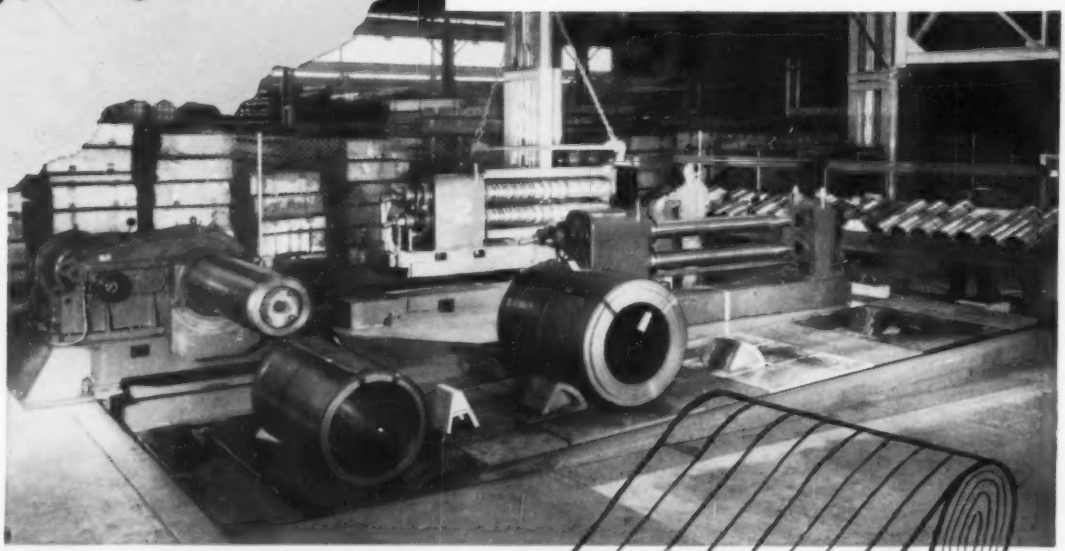
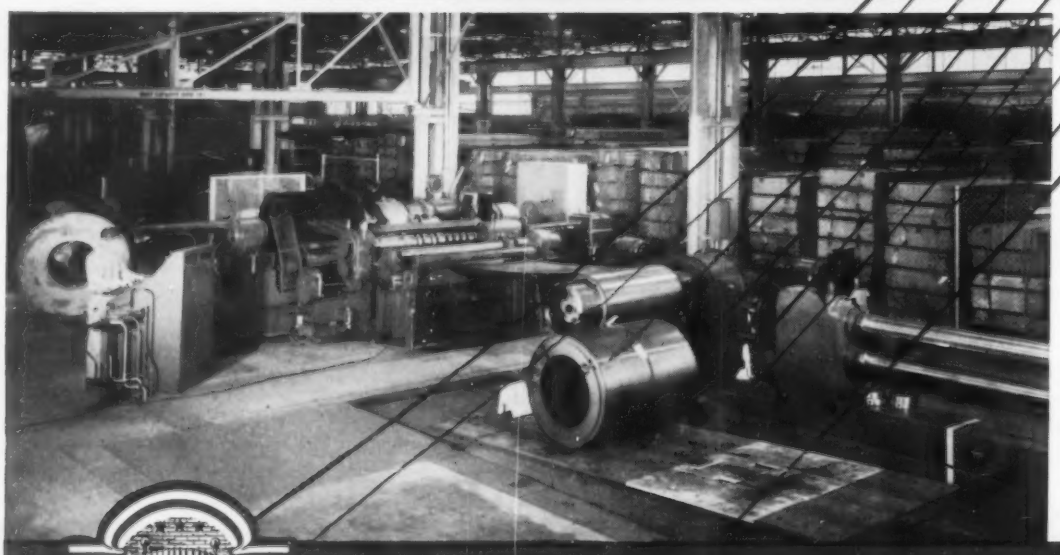
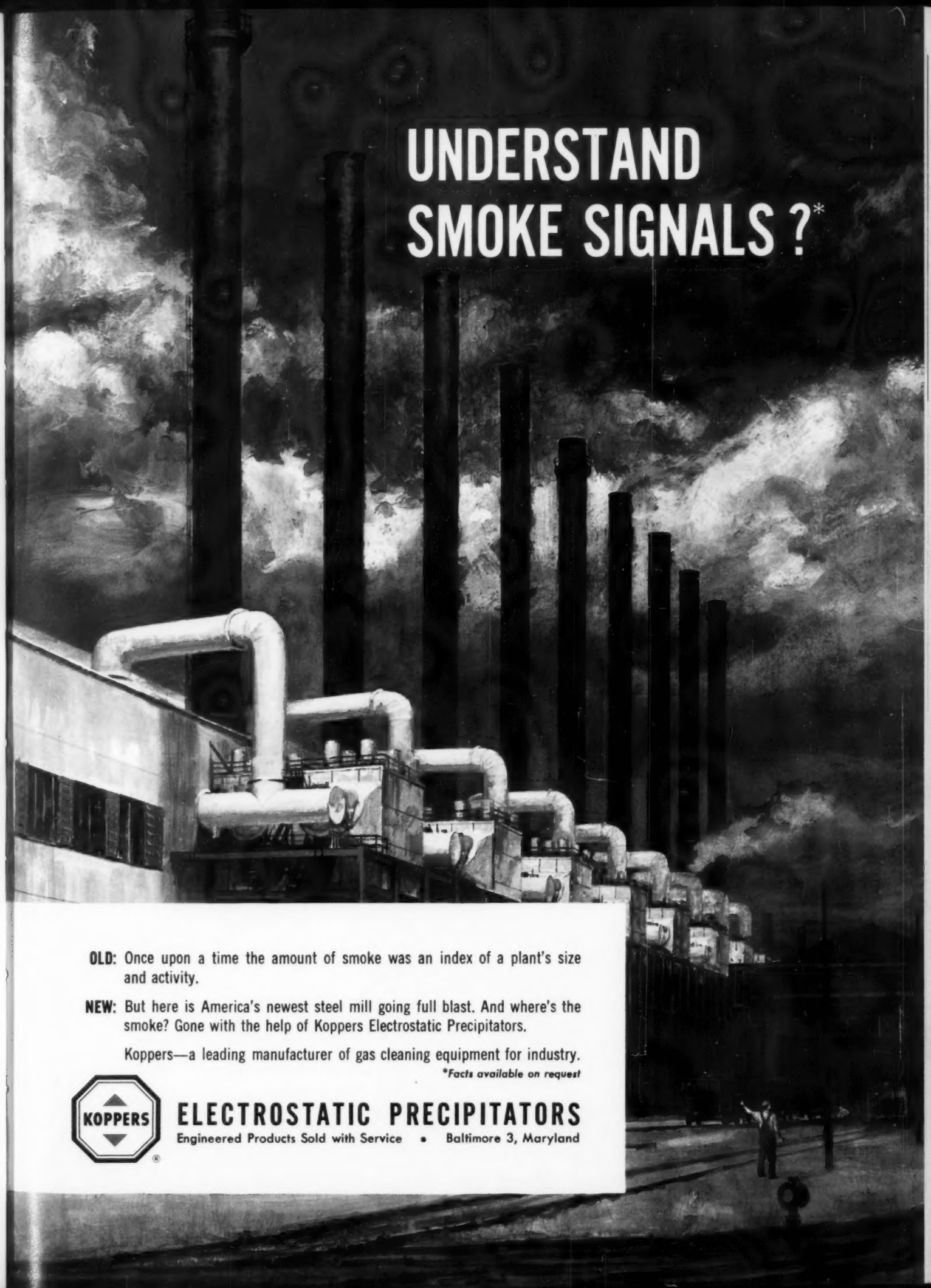


View shows coil and traverse, coil pay off reel, coil loading ramp and detachable slitter head.



Overall view of coiling line from entrance end.

STAMCO, Inc., New Bremen, Ohio



OLD: Once upon a time the amount of smoke was an index of a plant's size and activity.

NEW: But here is America's newest steel mill going full blast. And where's the smoke? Gone with the help of Koppers Electrostatic Precipitators.

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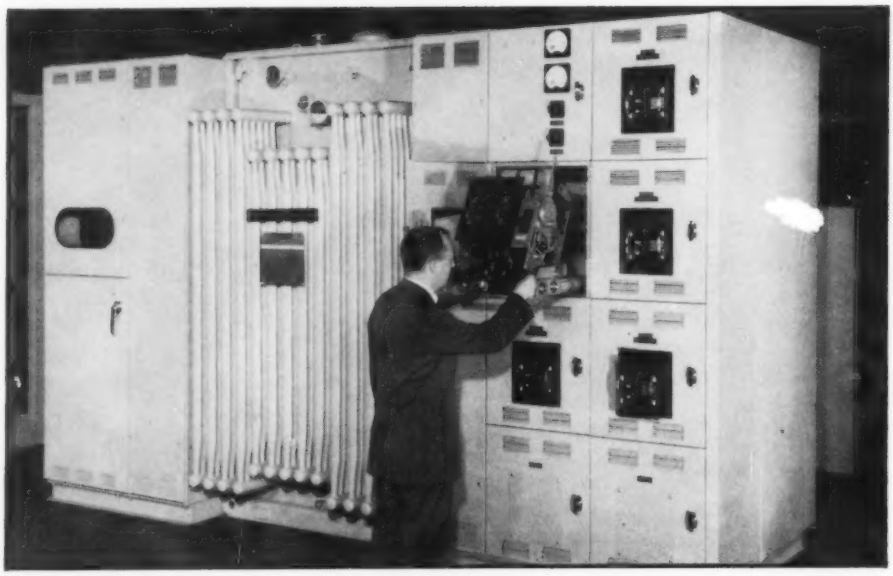

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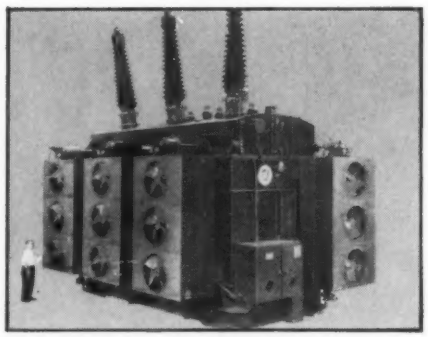

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PENNSYLVANIA TRANSFORMER DIVISION

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McGRAW EDISON

A number of repeater rolling mills are in operation in Europe and Japan and they have many advantages . . . . in addition some of the many rolling mill techniques and equipment described so thoroughly in this paper can undoubtedly be adapted with advantage to American operation . . . .

SWEDISH TYPE REPEATER MILLS

for high quality steels

By ERIK NORLINDH,
Morgardshammars Mek Verkstads AB,
Morgardshammar, Sweden

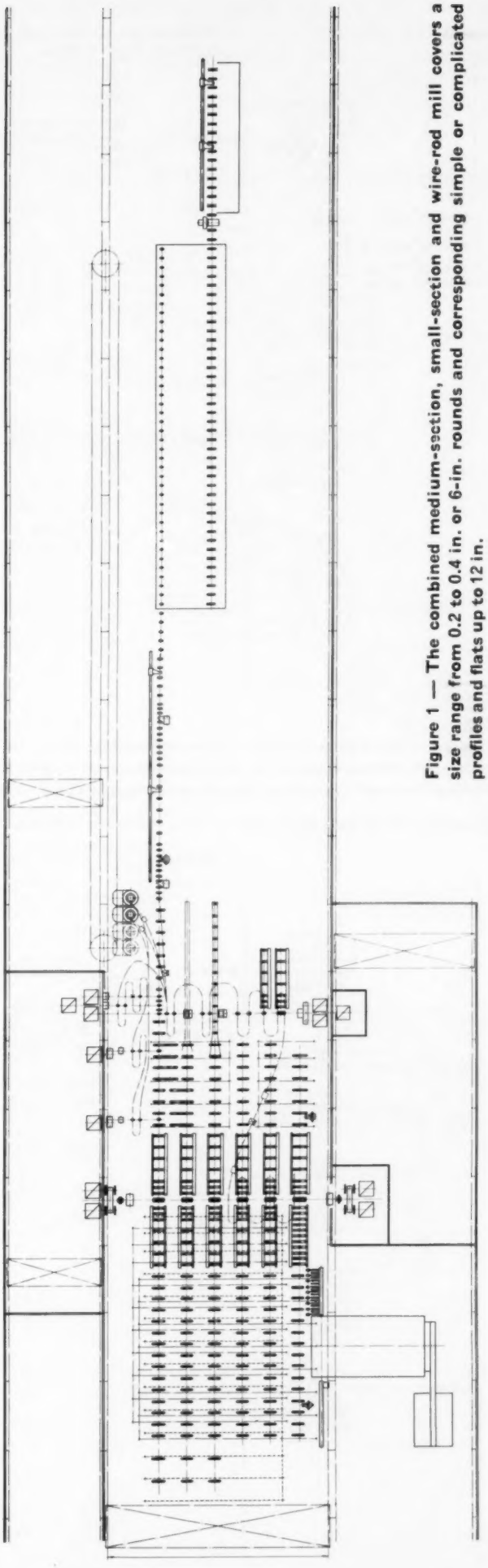


Figure 1 — The combined medium-section, small-section and wire-rod mill covers a size range from 0.2 to 0.4 in. or 6-in. rounds and corresponding simple or complicated profiles and flats up to 12 in.

THE problems, which the Swedish rolling-mill technicians have had to encounter, have arisen mainly due to the large size ranges to be rolled with small tonnages for each size and with varying steel qualities combined with low annual outputs. Due to the high initial installation costs it has been impossible to apply continuous rolling mills, but, by means of repeater rolling, the three-high and alternating two-high mills have achieved a high degree of perfection and automation.

Figure 1 together with the rolling schedules, Figures 2, 3, 4, and 5, and views of such mills, Figures 6 and 7, give an idea of the combined medium-section, small-section and wire-rod mill for 0.2 to 4 in. from 6 in. rounds and for corresponding simple and complicated profiles, and for flats of $\frac{3}{8}$ to 12 in. width.

The obtained output varies from about 7000 tons per year in the case of 2-shift operation and production confined to very small lots of high-alloys up to about 90,000 tons per year in the case of 3-shift and larger tonnages of each size, although the qualities may alternate from telegraph wire rod to stainless and high-speed steels.

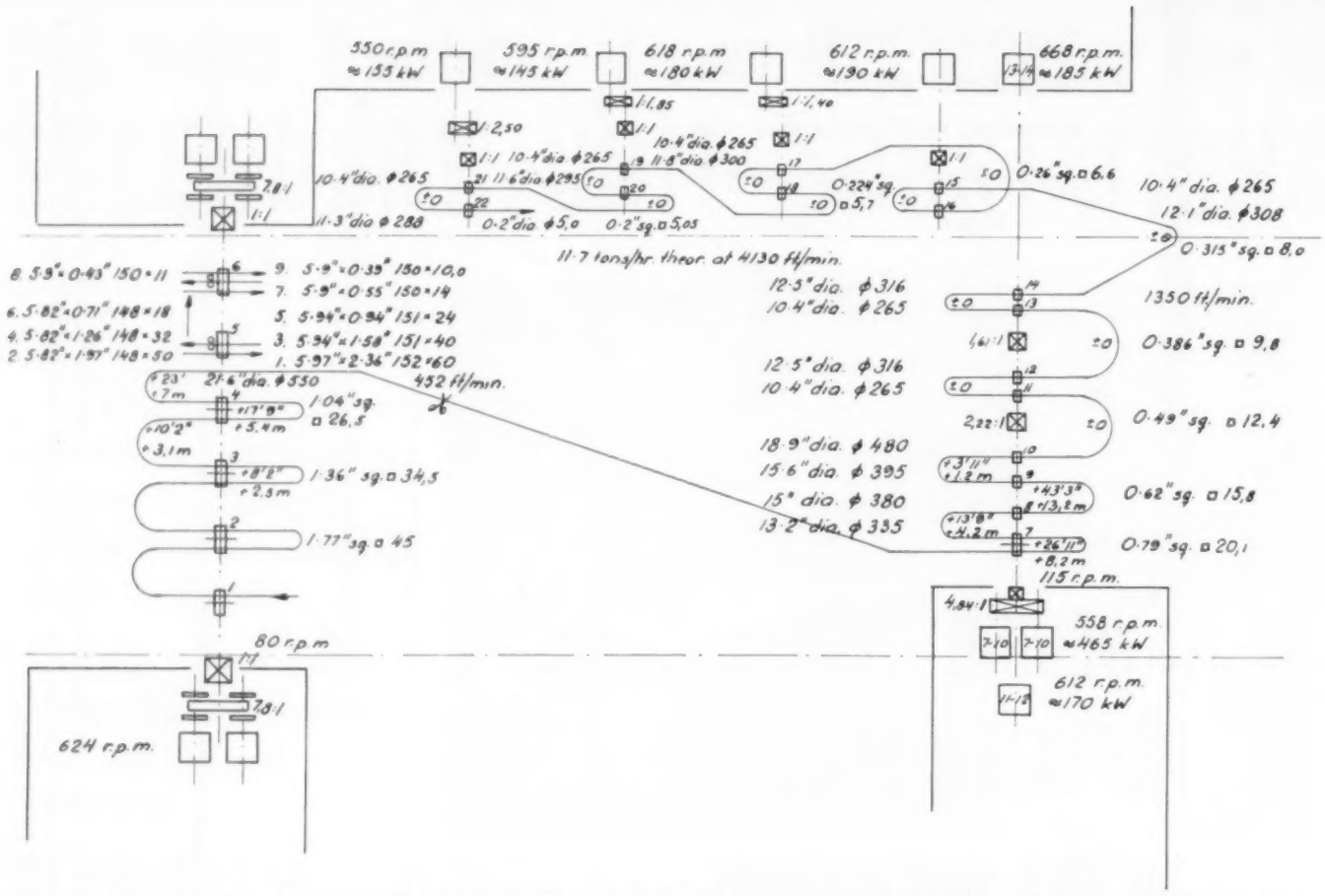
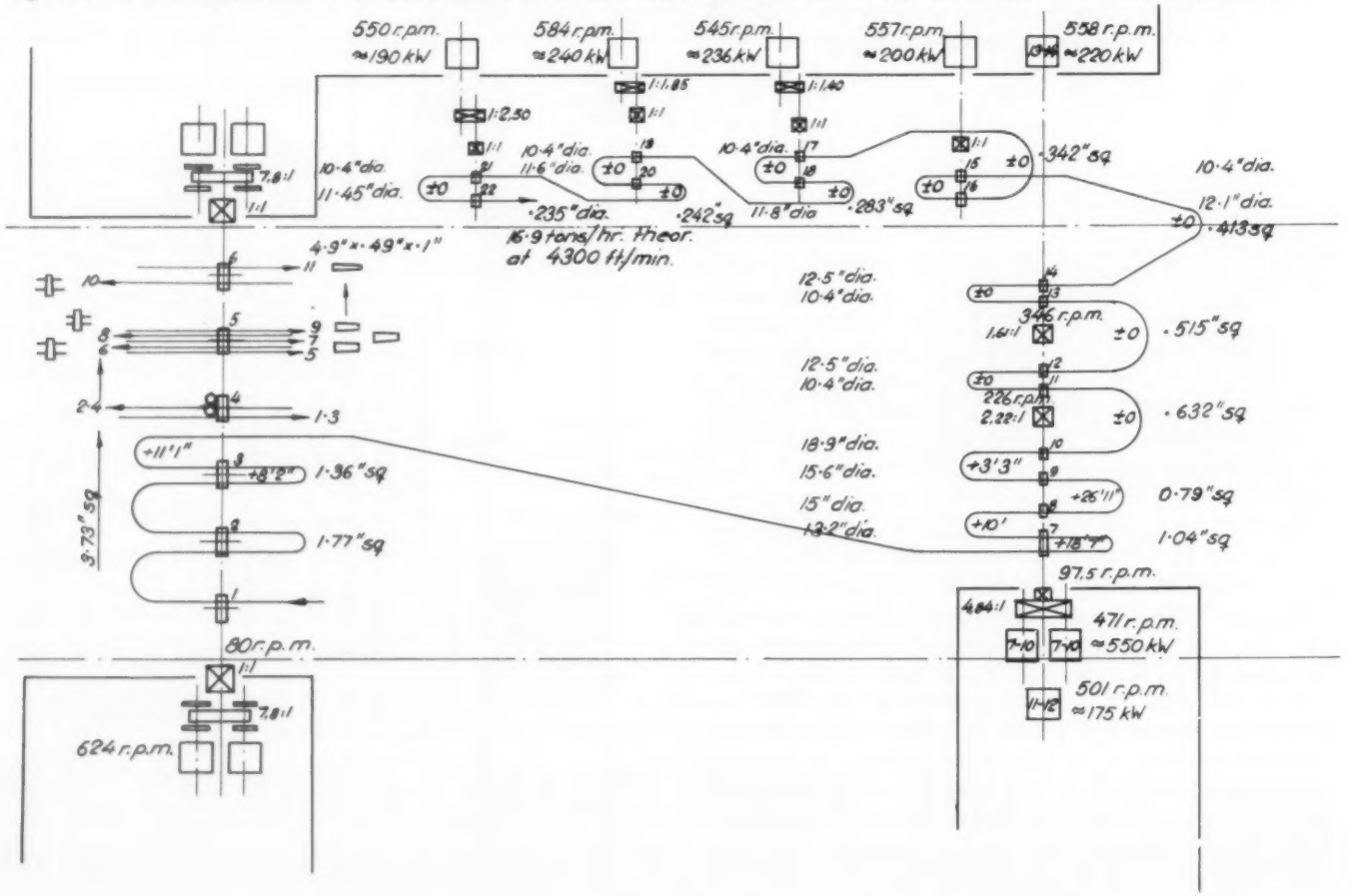


Figure 2 — Pass data for a 2-in. wire-rod and for 6 x ⅜-in. flats. During groove or roll changing in the intermediate and wire-rod trains, flats are rolled to avoid decarburization and to improve the surface conditions of the wire-rod. Loop growth for 550-lb billets are indicated. Power-consumption figures are given for ball-bearing steel.

Figure 3 — Pass data for 0.235-in. wire rod from -550lb billets alternating with beveled steel rolled in stands 1, 4, 5 and 6.



The medium sections must be rolled by hand, whereas small sections and wire rods from at least 20 ft billet lengths can be rolled completely automatically.

The introduction of the above mentioned combined mills has resulted in a noticeable transition in Scandinavia to the use of looping and repeating mills. This technical development which has not yet been discussed in the American technical journals, will here be described in detail, especially as these methods and this technique will probably be used to a certain extent even for high-producing merchant iron works in the future.

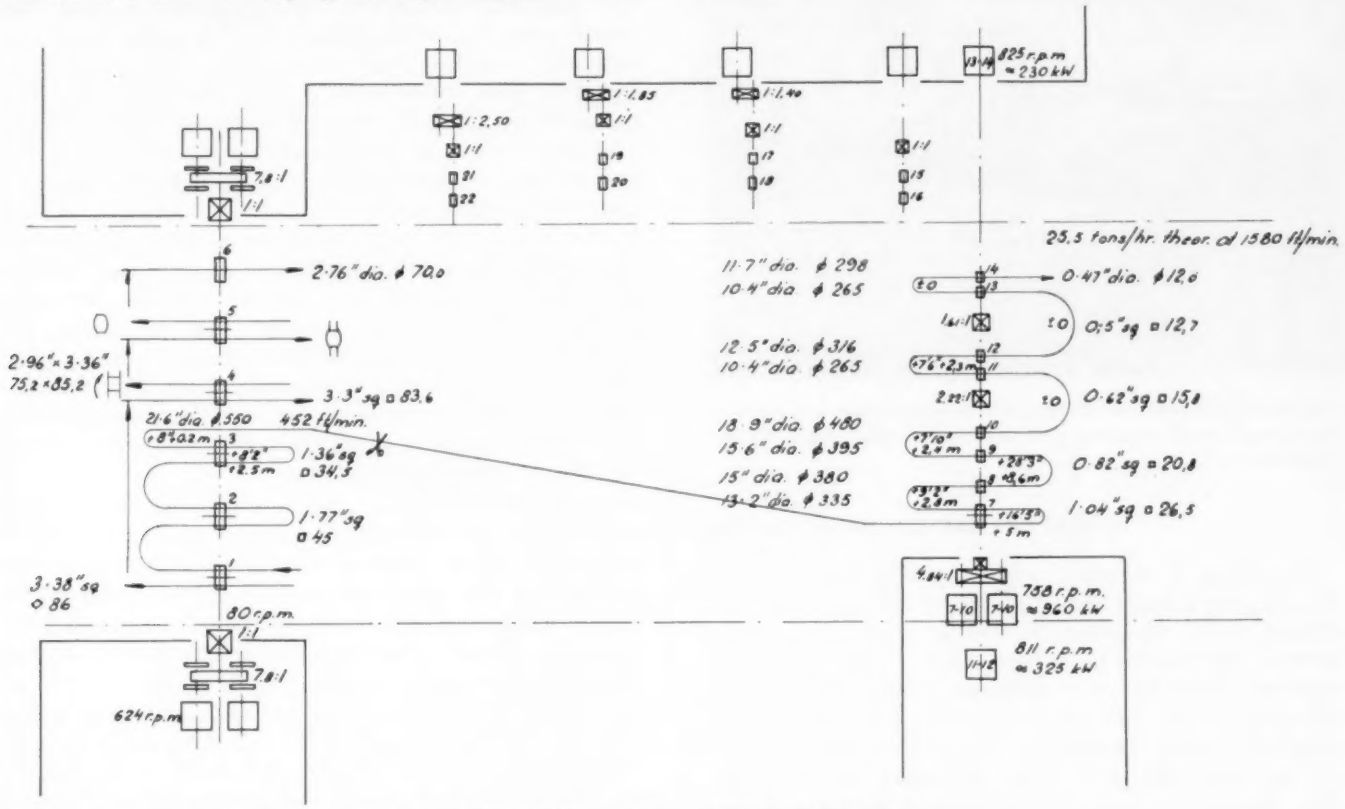
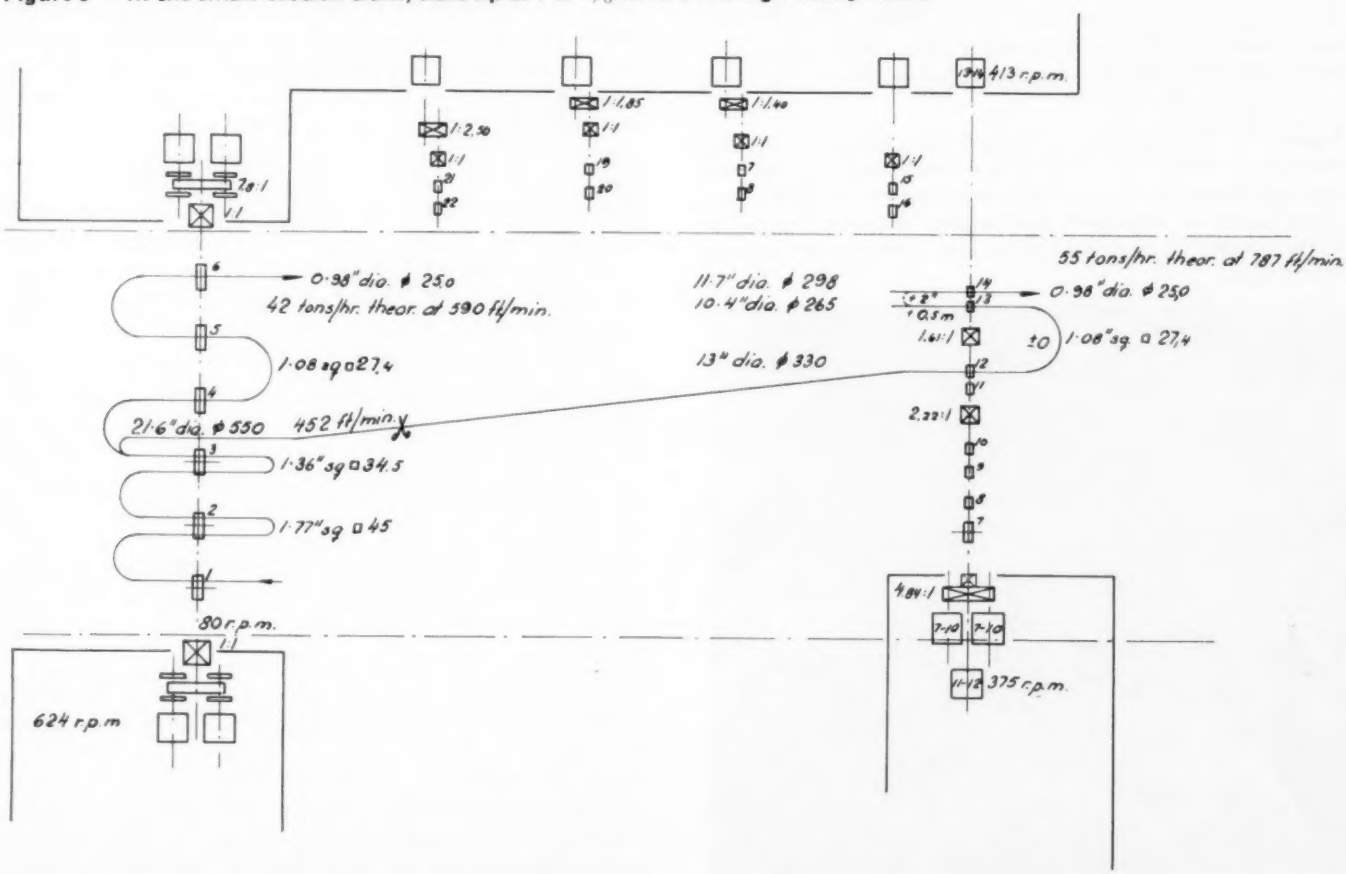


Figure 4 — Pass data for 0.47-in. diam from 550-lb billets alternating with 2.76 in. diam.

Figure 5 — In the small-section train, sizes up to 1 or 1⅛-in. diam are generally rolled.



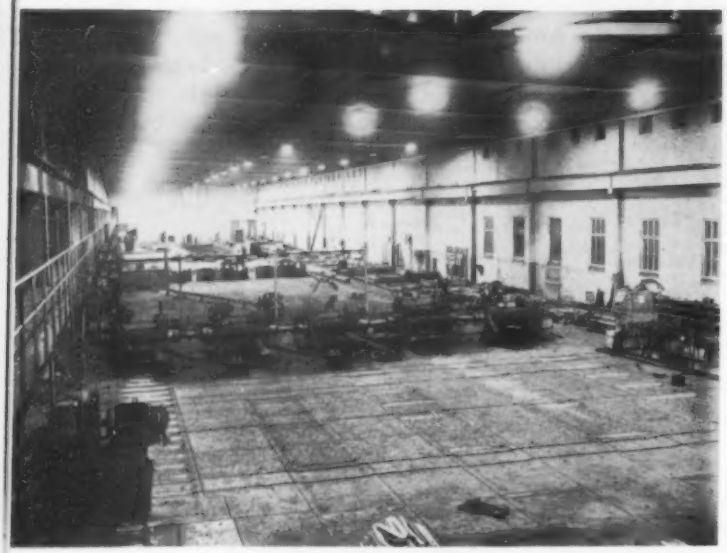


Figure 6 — Combined rolling mill is used in producing medium and small sections and wire rod at Söderfors Works, Sweden.

REPEATERS AND DELIVERY GUIDES

Repeating of squares has been applied during several decades, but it has proved to be more difficult to achieve reliable oval repeating. However, since the 1920's, several experiments have been made to introduce oval repeaters by means of twist guides. The experiments in question turned out successfully to a certain extent, especially when conditions were favorable and the rolling mills ran with large tonnages of each size. The experiments made in Sweden with high-grade steel in small lots turned out badly. Sometimes the oval repeaters worked reliably, but sometimes the results were only cobbles. Not until SKF Hofors Steel Works commissioned their new rolling mill in 1938, could the oval be repeated in a safe manner. That mill was

Figure 7 — Rolling wire rod at Söderfors Works. From the medium-section train the oval is automatically guided in a channel to the small-section train, where repeaters and roller guides are also used. Still smaller sizes are also rolled automatically in wire-rod trains, one of which may be seen at the left.

equipped with universal couplings, making it possible to obtain bars with straight front ends, which did not cause too large a resistance on passing the entry guide of the following stand. In rolling mills equipped with wobbler couplings which soon become worn and loose, the front end of the oval often forms a knuckle, so that it cannot pass the following entry guide, and consequently cobbles. Furthermore, the rolling mill was equipped with roller bearings with the result that the positions of the rolls did not change during rolling. The third and most important fact for the safe operation of the oval repeater was the procedure, whereby the repeater directed the oval sideways and downwards in such a way that the oval turned of its own accord to the vertical position independent of the steel quality and of the oval sizes and without the use of twist guides. Moreover, the repeater was made spiral-formed, so that a gradually diminishing bending radius aided in raising it, and afterwards, when the oval was guided straight to the entry guide, it was straightened out so that the oval was always very close to the vertical position on entering the guides.

Figure 8 shows an oval repeater with accessory guides used for breakdown ovals as well as for leader ovals. The bottom stripper rests at the front end on the roll and at the other end on the guide support. The upper stripper, Figure 9, is completely supported by the guide support. During assembly it is pushed against the roll groove and is secured with a wedge of soft iron. The distance between the upper and bottom strippers and the vertical opening of the following guide tube to the repeater must be fairly small, but not so small as in continuous rod mills with twist guides. Delivery guides and tubes that are too open cause wavy formations, Figure 10, since the oval meets with a large resistance when the roll bites. In the event of this wavy formation, the bar tends to lock, and the upper delivery guide may be thrown out. The funnel-shaped part of the delivery guides in contact with the rolls and the cone of the guide tube ought not to be too long for the same reason. The risk of this wavy formation is greater for soft iron. In the case of thinner ovals and when the following stand has a low speed in relation to the preceding stand, results in a violent throw-out. On the other hand, the lateral space should be quite generous, so that ovals with flakes, ragged ends, and overfills caused by pipe can pass through, so far as possible.

In the roughing trains and sometimes also in the first passes of the small section train, Figure 2, a constant speed is used, and the loops grow rapidly. The strains on the delivery guides and on the guiding tubes if used will then be great, and it is important that no wavy formations can occur. For the thinner dimensions the roll diameter and the reduction gear ratio must be chosen in such a way that there will be very little loop growth. The throw-out from the repeaters will then be soft, and the restoring force backwards for delivery guides and guiding tubes will not be so great.

The guide tube from the delivery guides overlaps the straight portion of the oval repeater, Figure 8, so that a suitably long straight part of the oval can throw out when the following stand has gripped the bar. For thinner ovals and softer iron the tube must overlap the repeater a little more. Variations in the distance between the grooves are absorbed by the guiding tube

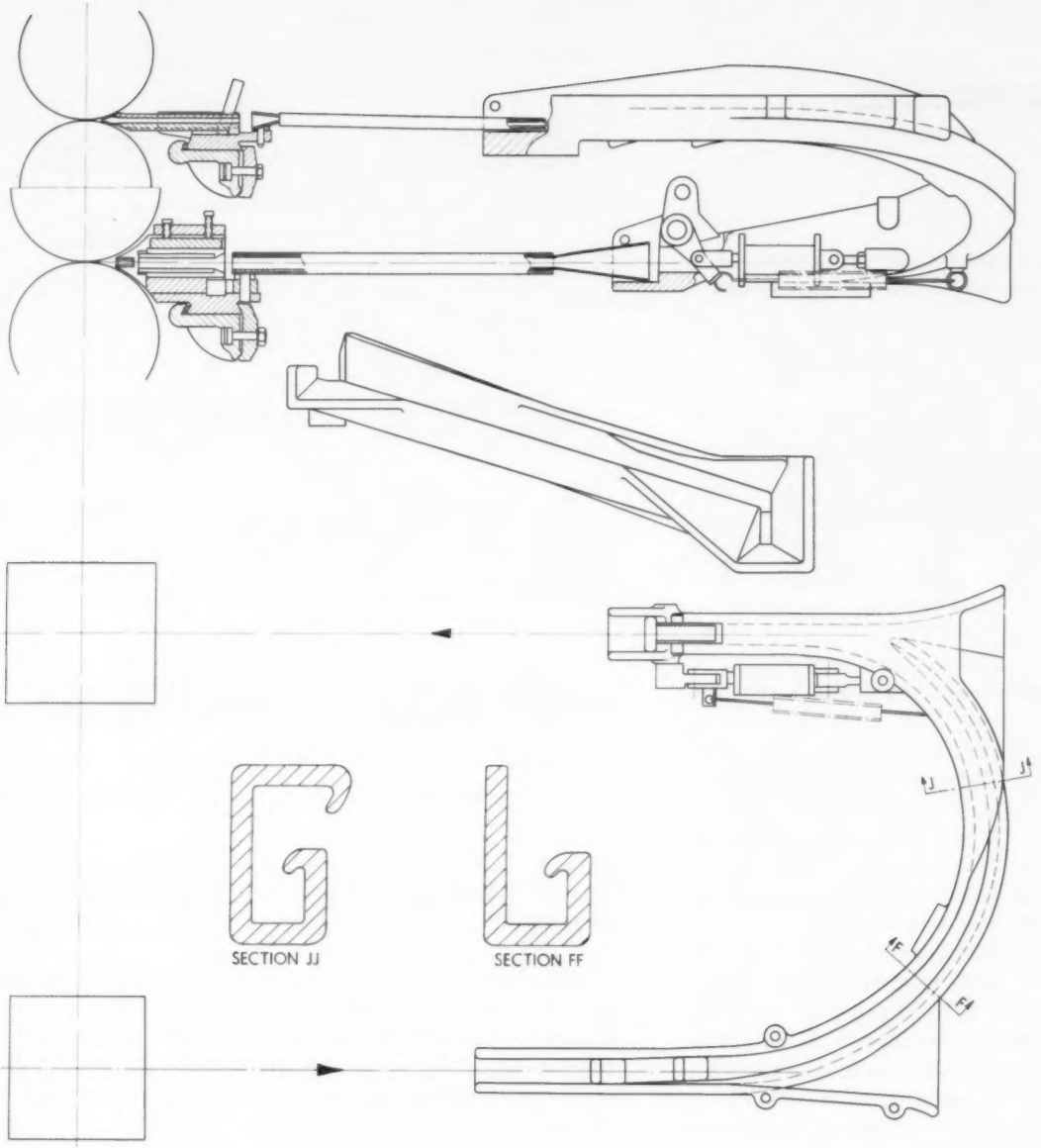


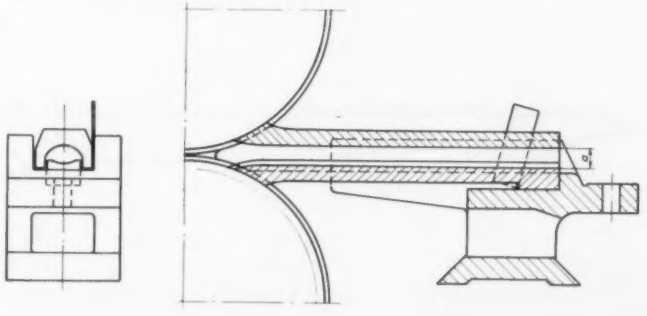
Figure 8 — Repeater and guides for leader and breakdown ovals.

from repeater to roller guide, as articulated repeaters should be avoided.

In the roughing trains the ovals are so heavy that it is difficult to secure the top stripper with a wedge, especially when rolling the hardest steel qualities. Therefore the top stripper is fixed with a screw as in Figure 11. This is an advantage, as the tip of the delivery guides does not there become worn. As the groove of the delivery guides is relatively spacious for the heavy ovals, it very seldom occurs that the delivery guides are broken or thrown out. Even billets with so heavy pipe that they would normally be remelted, have in large quantities been successfully rolled to $\frac{3}{4}$ and 1-in. reinforcing bars with repeater rolling. Experience showed that it was impossible to roll these billets in a continuous mill.

In the beginning a design according to Figure 12 was used for oval delivery guides, and the upper and bottom halves were fixed longitudinally in relation to each other and could not be set in more than one way. When the rest bar had been correct adjusted vertically, the delivery guide was pushed forward to make contact against the roll groove and was secured in the rest bar with a screw, and after that the repeater was put direct on the delivery guides in the locating hole. These delivery guides were simple and practical but had the great disadvantage that they could not be used for merchant iron with pipe and flakes. If the groove of the delivery guide is blocked by a flake or an overfilled oval, the delivery guide is broken and thrown out. It will take too long a time to remove the cobble and install another delivery guide. However, this type of delivery guide functions very well in mills with only high-grade steel. Attention is drawn to the fact that

Figure 9 — Delivery guides for ovals in the intermediate and wire-rod trains and for squares.



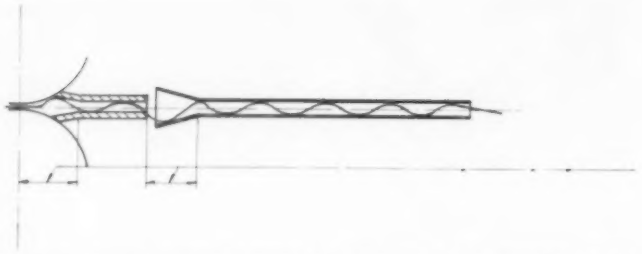


Figure 10 — Use of too long funnels and too spacious orifices in the delivery guides and guide tubes causes waves.

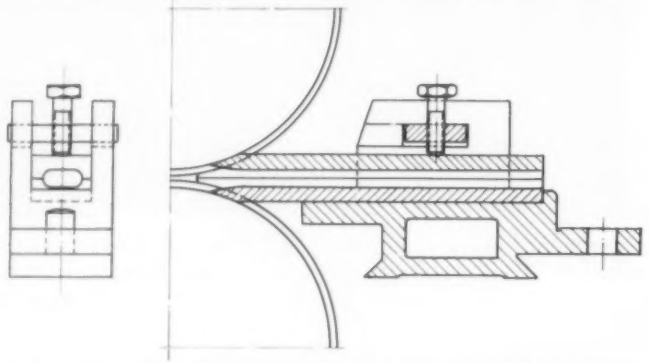


Figure 11 — Delivery guides for ovals in the roughing train.

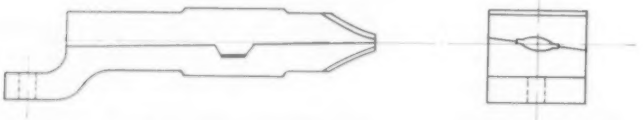
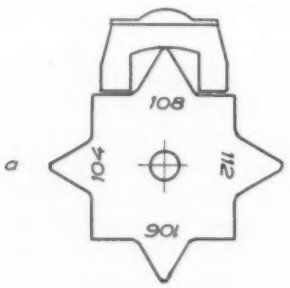


Figure 12 — Delivery guides of this type are suitable for ovals if exclusively hard steel qualities are rolled.

the oval groove which is somewhat twisted does not serve as a twist guide but has been given such a design in order to permit finishing or breakdown ovals to twist freely, as the first end passes the oval repeater. The short distance from the oval stand to the oval repeater is advantageous from the point of view of reliability, because the oval is not apt to enter the bent part of the oval repeater with an unfavorable twist angle, caused by overfilled or an under-filled square or because the oval grooves in the rolls are not placed exactly over each other.



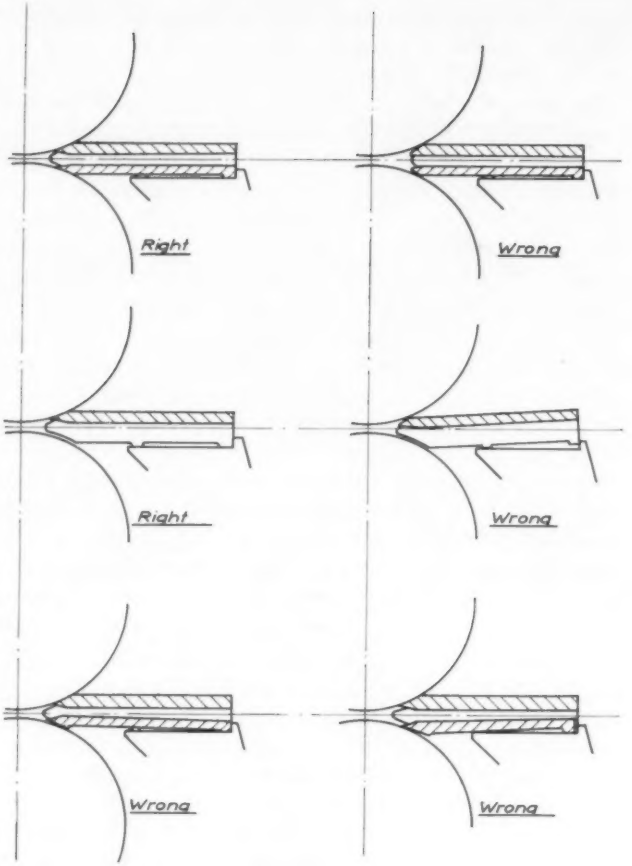


Figure 13 — Some wrong and right settings of the strippers are shown.

It is of great importance for reliability of operation that the delivery guides are set in a right manner. Figure 13 shows some common mistakes which would never occur, if keen-eyed people set the guides. Figure 14 shows suitable gages to control the dimensions of the top and bottom delivery guides. Figure 15 shows an arrangement for adjusting of top and bottom delivery guides. This can also be done in the stand after the roll-changing in the roll change shop, because both the ordinary set of delivery guide and the spare delivery guides should be tested before they are sent to the rolling mill. Bottom delivery guides which have been too short due to wear, are lengthened by welding at the back. Loose shims should be avoided.

The right setting of repeaters can be checked by means of equipment such as in Figure 16, or by means of a small level. Generally a pocket spirit level is used. Such tools should be used, because it will then always be possible to keep the most favorable settings. In the case of reasonable rolling reductions, it is possible to roll

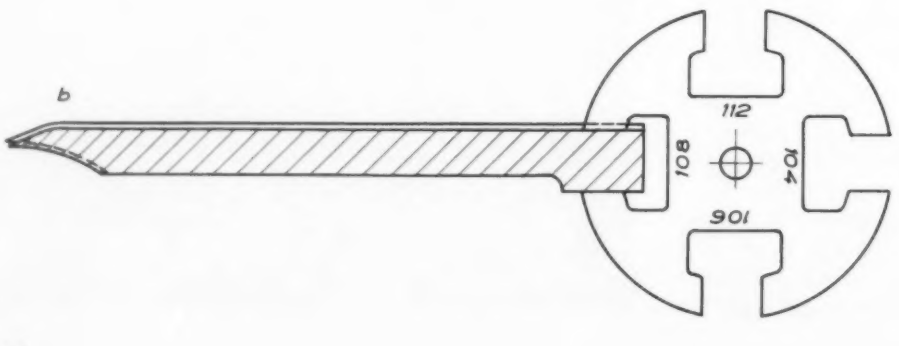


Figure 14 — These gages are used for checking the size of the strippers.

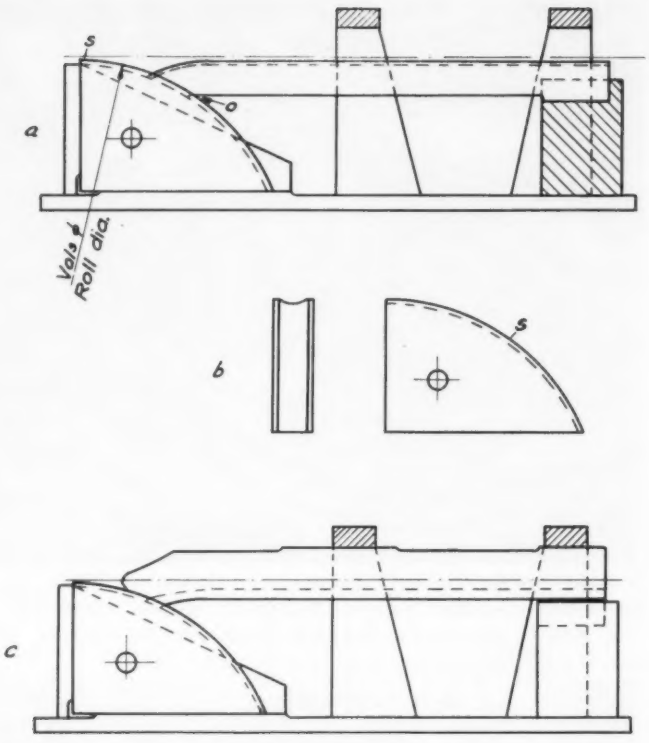


Figure 15 — Arrangement for checking the contact against the roll groove.

all steel qualities from telegraph wire rod to stainless and high-speed steels by merely changing the roll gap.

The setting of the right height for the rest bars is often made by means of a template, Figure 17. If the rest bar is too high the template tilts over the front edge against the rest bar and vice versa. Of course, the rolls must first be set to the right clearance. It is, however, more usual to aline the rest bar height relative to the roll chock by means of a rule, as shown in Figure 18.

In the medium section and roughing mill the repeaters are usually located directly on the delivery guide supports, Figure 19, and the guide tube from the repeater to the roller guides absorbs the longitudinal forces, rendering this design very stable. It is important that the repeaters stay rigid, otherwise the pushing forces are absorbed by the yielding of the repeater. In this case the repeater is made for double looping. Figure 20 shows the same repeaters seen from the square side, where 1.62-in. (41-mm) square is repeated from stand 2 to stand 1 and 1.26-in. (32-mm) square is guided through a tube below this repeater to another repeater with 40-in. span as it passes from bottom position to top position in the second stand. The snap shears in these repeaters can only be used for low alloy steel for such heavy sections, because the bar otherwise slides between the rolls.

The repeaters in the small section and wire-rod trains, Figure 21, rest on supports which fit into tubes in the floor. When the repeaters and the supports are removed the floor will be unobstructed and it will be possible to roll by hand. Groove changes are here made so often that it has proved to be more favorable to offset the repeater in order to get the guides more accessible and easier to remove. As for high-grade steel it is necessary to make sure that the sections are suitably filled and that the grooves are exactly over each other. Regarding merchant iron it may be questioned whether the oval repeaters should be placed close to the delivery guides or not.

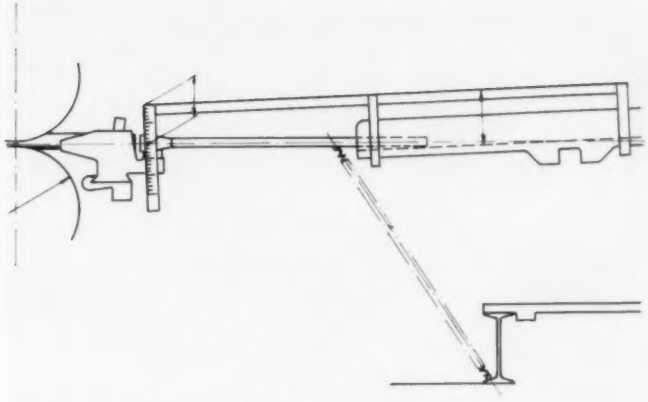
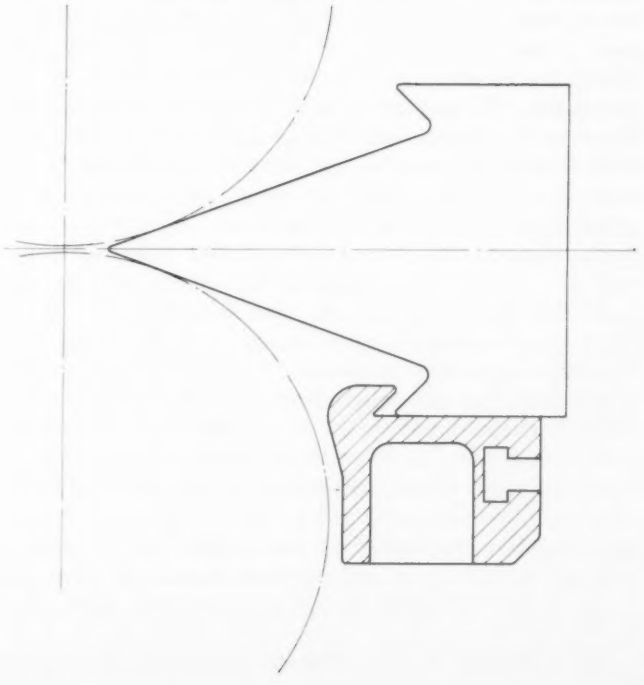


Figure 16 — Apparatus used for setting the repeaters to the right inclination.

Nowadays, all repeaters are made with snap shears, which can be operated by an air-pressure cylinder. It is thus possible to cut an end to check the dimension and the surface, and it is also possible to stop a bar or to cut it off in case of cobble, so that the whole bar does not gather in one, inconvenient, place.

Without exception, rolling mills today are designed so that the oval repeaters go from the upper position to the bottom position. This gives a throw-out upwards and outwards, which means that it is fairly easy to increase the pushing force of the oval without the risk that the oval is once more forced down into the repeater. Photoelectric cells with throw-out devices are not used and the repeaters work reliably without twist guides or moving parts. Oval repeaters going from the bottom position to the upper position are in fact used somewhere, but as the throw-out is upwards and inwards, the outer edge of the repeater may easily catch the oval after the throw-out, and the bar becomes cobble.

Figure 17 — If the rest bar is too high, the template tilts over the front edge against the rest bar.



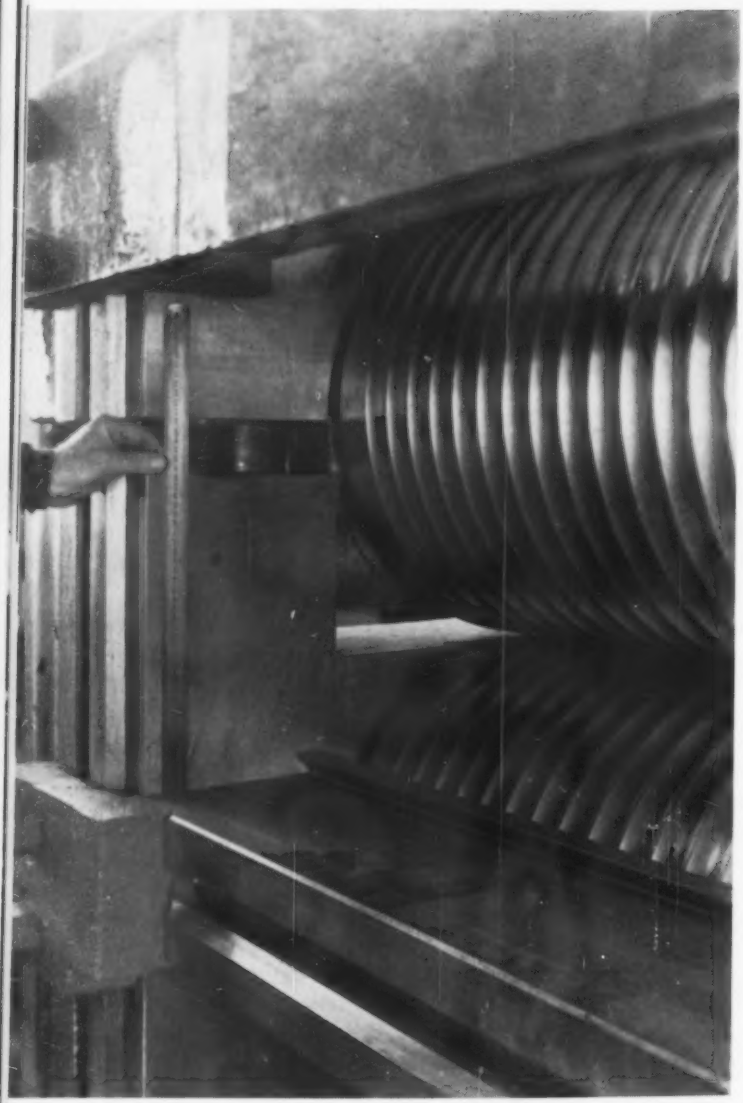


Figure 18 — In the case of the newer mill stands a rule is used to set the rest bar vertically.

The inverted oval repeaters with throw-out downwards have been tested for high-grade steel in Sweden but without success. It seemed to be difficult to adjust such a repeater so that it worked reliably. Furthermore, it was difficult to observe the violence of the throw-out. In an oval or square repeater with upward throw-out running with speeds up to about 2000 fpm it is possible to observe the throw-out and adjust the setting so that great pushing force is obtained without running the risk of the bar going into the repeater once again after the throw-out. For higher speeds the eye cannot perceive the violence of the throw-out, but the kinetic energy of the bar will then be sufficient to overcome the resistance in the roller guide. An exceptional instance may be mentioned: 0.22-in. (5.5-mm) telegraph wire rod was rolled, and the rollers of the roller guide had by chance been set so close that the leader oval was rolled between them with such a great reduction that the finished rod becomes 0.14-in. wide and 0.22 in. in height (3.5 x 5.5 mm). Notwithstanding the final speed of only 2400 fpm (12 meters per sec) the repeater with its normal setting, managed to push the oval through, and several rods were rolled in such a way.

The case often arises where it is a question of whether

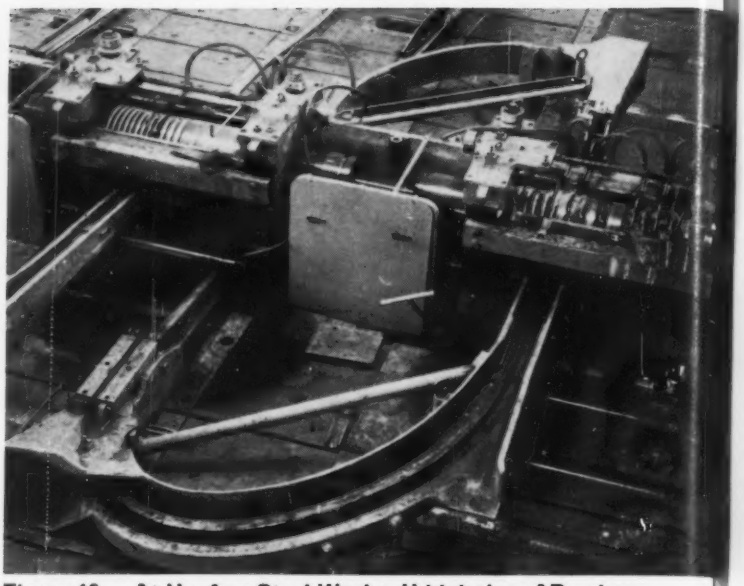


Figure 19 — At Hagfors Steel Works, Uddeholms AB, when the billet is reduced by hand to 2.05 in. square, the following oval is looped by means of a repeater to the second stand and then repeated to the first stand again.

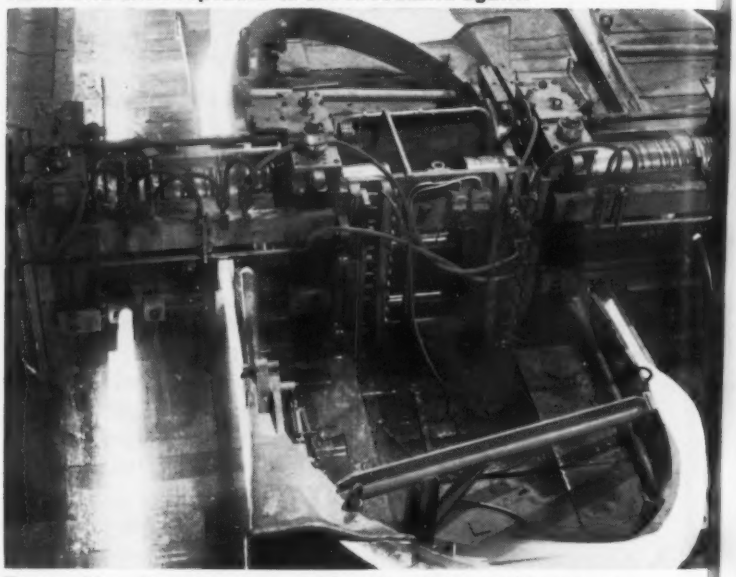
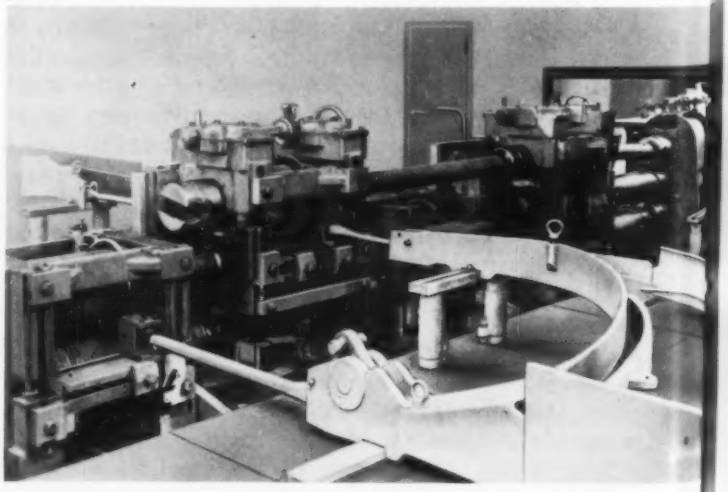


Figure 20 — On the square side, the tilting table can operate below the repeater. A 1.62-in. square is repeated from stand 2 to stand 1 and 1.26-in. square from the bottom to the top position in stand 2.

Figure 21 — At AB Kanthal, Hallstahammar, in the intermediate and wire-rod trains the repeaters rest on supports.



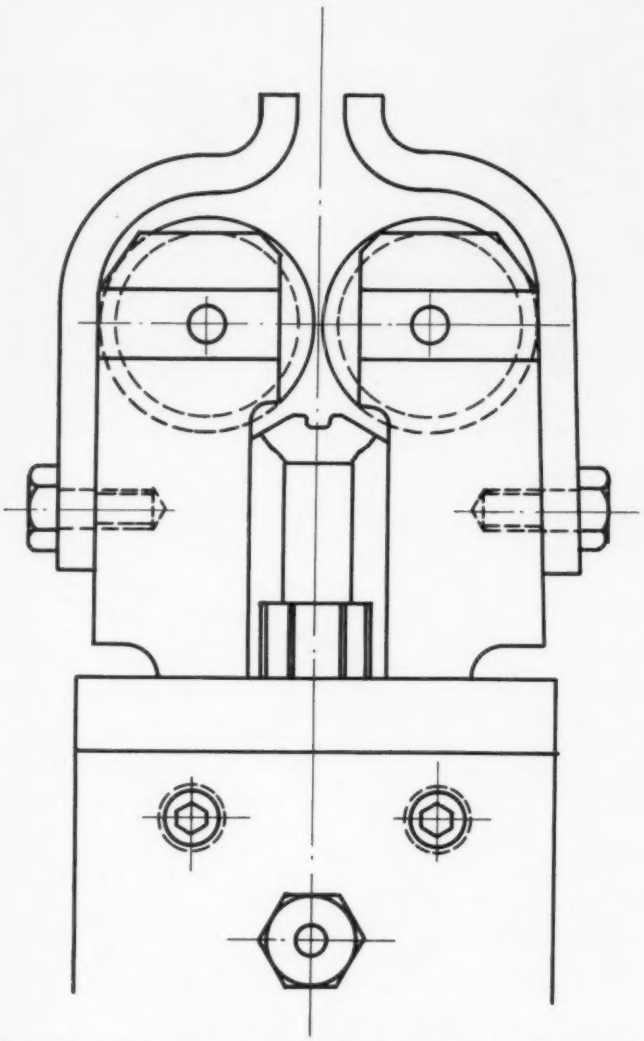


Figure 22 — In trains with wobbler couplings additional guiding flaps are required to prevent the knuckled front end from entering the adjacent groove.

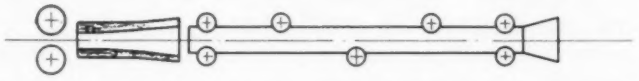


Figure 23 — For straightening the bend caused by the repeater throwout, guide tubes with rollers are inserted in front of the roller guides. The entry guides are then provided with a long funnel.

oval repeaters should be built in in old trains with wobbler couplings or not. If a train has many stands with fabric bearings, driven from one pinion stand, it is, practically impossible to get reliable operation even if couplings are changed very often. Some of the couplings often have the play in the wrong direction when the bar grips, resulting in such a sharp knuckle of the front end of the bar that it cannot pass the entry guides. Figure 22 shows the additional guiding flaps which are required to prevent the front end of the oval from entering the adjacent finishing groove. In trains with wobbler couplings it can often be observed that the oval at the delivery guides swings up and down. This waviness cannot be controlled without special straightening rolls, Figure 23, resulting in overfill alternately on one side to the other in the finishing groove. With the exception of roughing mills with only a few stands driven from one pinion stand, it is generally no use introducing repeaters in mills with wobbler couplings.

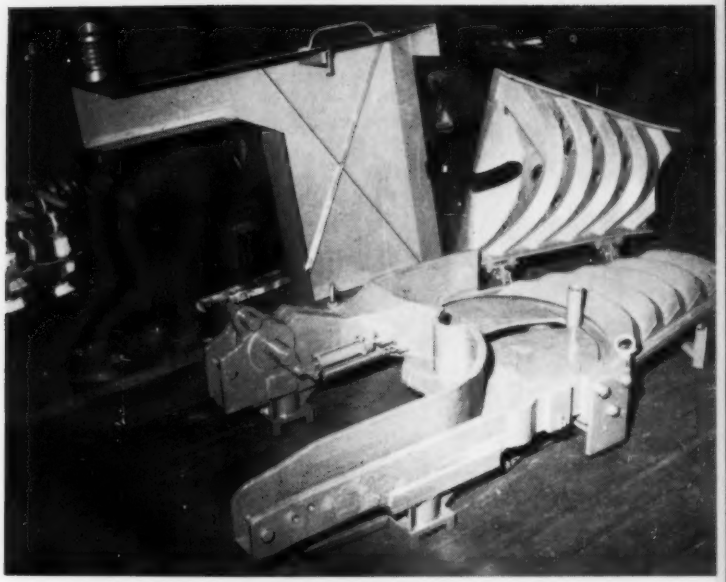


Figure 24 — Loop-regulating repeater for thin squares are combined with whip channel.

Even for roughing mills it is more economic to purchase new stands with universal couplings.

To avoid alteration of sections in many stands of the rolling mill when rolling intermediate sizes of rounds the breakdown oval preceding the leader square is generally exchanged for a diamond section which without difficulty can be repeated on the oval side. The pass sequence will then be one ordinary breakdown square—diamond—leader square—leader oval—round.

Diamonds are repeated for obtaining sharp-cornered square, but they cannot always be used for heavier sizes due to the fact that the corner is damaged at the throw-out.

The ordinary oval and square repeaters can be used for hexagons and octagons, for certain flats, where the difference between the width and the thickness is sufficiently large as well as for strips up to 2 x 0.08 in. (54 x 2 mm). For flats with a small difference between width and thickness, hand rolling has to be used. For strips, up to 8 x $\frac{3}{16}$ in. (200 x 5 mm) especially designed strip repeaters without movable parts are used.

The oval-round series for breakdown passes has only been used in rare cases, due to the fact that the reductions are too small for the number of stands normally used. As a perfect product is obtained when using the oval-square series, no serious experiments have been made with the oval-round series which cause certain complications, e.g., the oval entry guides must keep the oval steady in the round groove.

When rolling soft iron the reductions should not be too great, because the breakdown ovals become thin and slack and are not so reliable in passing the repeater and entry guides. This is the case only for smaller sizes at speeds below 2000 fpm (10 meters per sec). If pipe or segregations pass the oval groove with great reduction, the oval will spread more than if the reduction is moderate. Thus great reductions must generally be avoided, when rolling merchant iron. As for hard steel qualities the repeater reliability will not be influenced by heavy reductions, but nevertheless, moderate reductions should be chosen enabling the use of the same roll grooves for steel qualities with different

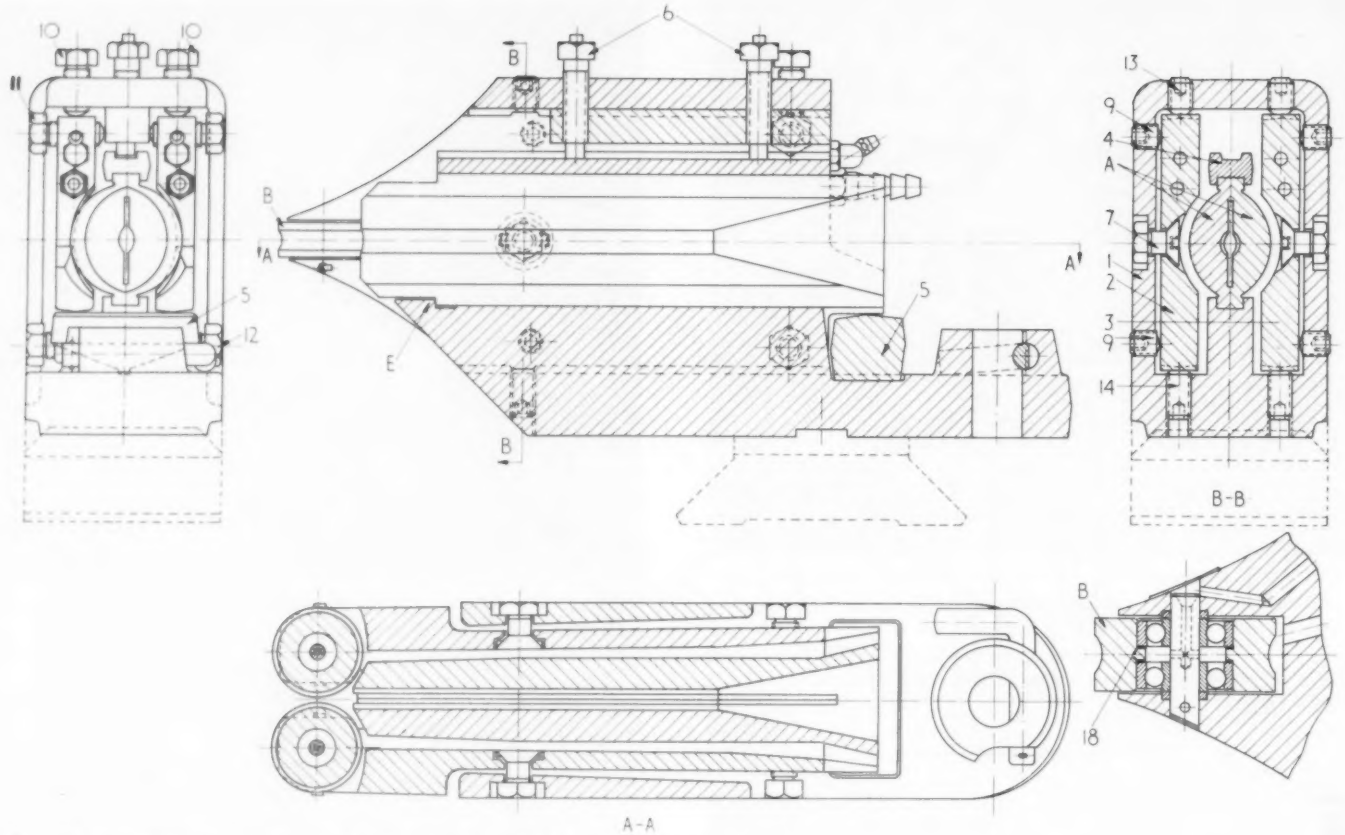


Figure 25 — Roller guide is used for finished size of 0.2 to 47-in. rounds.

spreading tendencies without running the risk of overfill. Besides this, a thicker breakdown oval is not so apt to fold at the surface, producing defects which will be accentuated during rolling and give rise to seams. Furthermore the grooves in this case are not worn out so quickly.

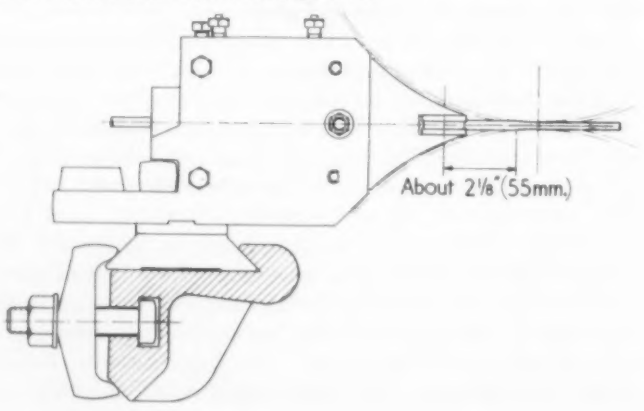
The repeaters on the square side are made in about the same way as in the U. S., but generally a longer straight part for the throw-out is used. A guide tube from the delivery guide overlaps the straight part more or less, and by doing so it is simple to adjust the pushing force, and it is also possible to study the violence of the throw-out if there is any risk of the square being caught by the outer edge of the repeater after the throw-out.

If required, a square repeater can be situated relatively far from the stand, provided the delivery guides and their guide tubes are made in such a way that wavy formation does not occur, Figure 10.

Among special design repeaters may be mentioned loop-regulating repeaters for squares, Figure 24. These repeaters adjust the speed of the following wire-rod train, and the movement of the loop roller is transmitted to a rheostat, which performs the speed control via a magnetic amplifier or thyratrons. Recently the loop-regulating roller has been replaced by a photoelectric cell so designed that it senses the position of the rod and controls the speed. The loop-regulating repeater is usually assembled with a whip channel which controls the movement of the tail-end and thereby prevents double-back ends or pig-tails.

To prevent scratching of the rolled stock as far as possible, repeaters as well as delivery guides and entry guides are made of cast iron.

Figure 26 — Fastening of roller guide 12 to the rest bar. In spite of the distance from the center of the guide rollers to the contact point with the roll groove when rolling 0.2 in. rod, the oval is perfectly guided.



ROLLER GUIDES

As practically only roller guides are used for repeater rolling in Scandinavia at present, they will be described in detail.

Figure 25 shows roller guide No. 12 for 0.2 to 0.47 in. (5 to 12 mm) diam or corresponding sections. The two halves of the entry guide (A) are mounted in the roller-guide housing with two leaf springs (2) and (3), and their roller B next to the rolls. The entry guides are pushed into a groove in the guide box and are held securely by a loose top guide (4) and screws (6) on top of the roller-guide housing. A front offset E prevents the entry guides from advancing, in case the end of the oval should be double-folded or so ragged that the oval is pulled off. The grooves of the entry guides for 0.2 to 0.47-in. (5 to 12-mm) rod are made about ⅛ in. (3 mm) wider than the oval, so that the

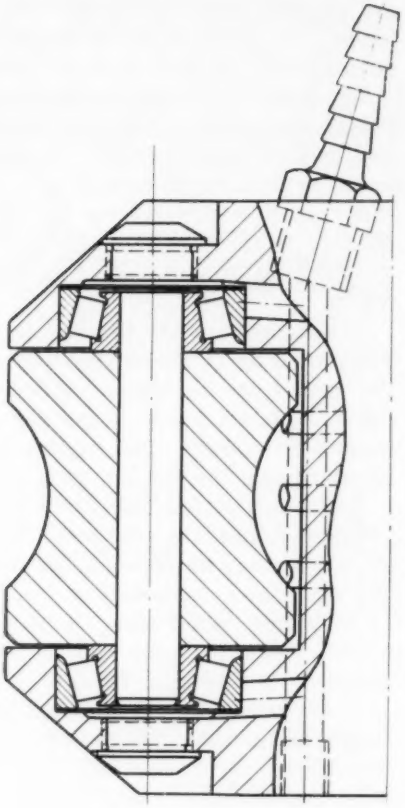


Figure 27 — Rollers for roller guide 45 and larger.

entry guides do not cause any appreciable friction when the oval is introduced into the pass. The entry friction guides are intended to lead the oval to the groove in the roller, to straighten bent rods, and to protect roller and leaf springs against overloading caused by double-folded ends or ragged material.

The rollers hold the oval securely so that it cannot be displaced laterally or tilted. Figure 25 bottom-right shows how the roller is mounted in the leaf spring. The outer ball-bearing race is reduced by grinding on one side so that washers (18) can compensate for the wearing down of the bearing. The washers should be thick enough to give a fairly tight fit.

To obtain the best possible guiding of the oval it is desirable to have the guide roller as near the rolls as possible. The rollers guide the oval perfectly, in spite of the fact that the distance from the guiding of the oval between the guide rollers to the contact surface of the rolls is about 2⅛ in. (55 mm) at 0.2 in. diam, Figure 26.

There is no room for labyrinth seals, etc., and so the only sealing is the clearance against the end surfaces of the roller. Trials have just started to arrange a sealing.

All roller guides running at higher speed than about 1500 fpm (8 meters per sec) should be provided with

Figure 28 — The roller guides here are used for 0.2 to 8-in. rounds and corresponding sections.

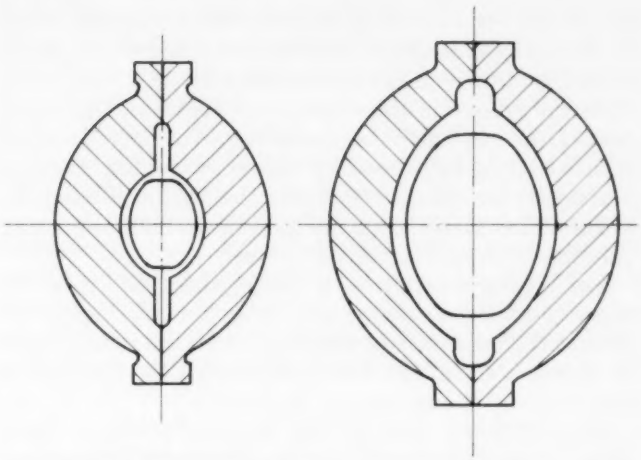


Figure 29 — The entry guide groove is rather spacious but if made too wide the oval may have difficulty in entering the roller groove.

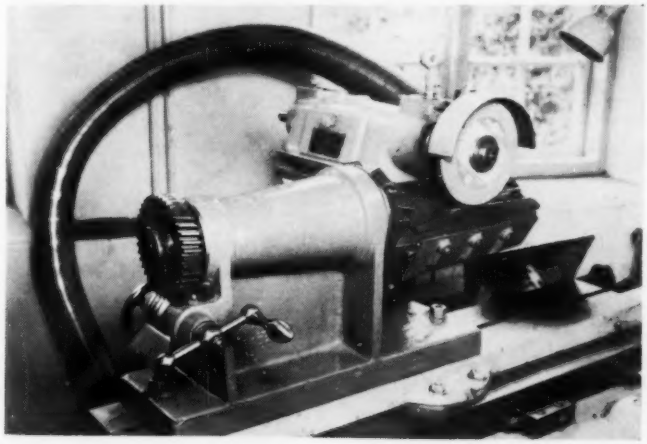
oil mist lubrication. because the life of the bearings is increased to more than twice compared with cases where grease is supplied every half hour. For lower speeds, automatic grease supply should be arranged. Hitherto, it has not been possible to prevent water and scale from entering the bearings giving rise to wear.

The leaf spring is fixed longitudinally by screw (7) in the guide housing (1). Just near the tension screw (7) the leaf spring is supported by pointed pressure-screws (9) which absorb the reaction pressure from the bar against the roller and keep the rollers separate when they are not under load; otherwise, the roller would be broken by the shock from the front end of a bar at speeds of 4000 to 6000 fpm (20 to 30 meters per sec).

The adjusting screws (11 and 12) for the leaf spring are supported by inserts in the guide housing and are placed inside the side of the roller guide. All screws that require adjustment during rolling are accessible from the front of the stand. No lateral space is therefore required outside the guide box for gaining access to the set-screws, and so the guide box assembly can be located close to the mill housing. As the rollers are mounted on leaf springs, the springs of both rollers yield equally if the thickness of the oval varies, so that the oval remains in the center of the groove.

Vertically, the leaf spring is fixed with adjustment screws (13 and 14) just in front of the central tension screw (7). By means of a balance (5) and the upper set-

Figure 30 — Device is used for grinding the entry guides.



screws (10), one roller can be lifted by the same amount as the other is lowered. The oval is tilted or displaced vertically, but its height is not altered.

As the groove in the entry guides is wide, the thickness of the oval may vary and the oval may be tilted without being influenced by the entry guides. There is practically no risk of scratching the bar or of adhesion of the rolled material to the guides, which is especially valuable when rolling stainless steel.

For rolling in continuous mills, the grooves of the entry guides are formed as a long funnel, Figure 23, so that the twisted oval does not touch the entry guides at all when the guides have transferred the first end of the oval into the grooves of the rollers.

In continuous rolling mills the oval must be made thin, to enable the twisting delivery guides to function. When possible, the oval should however, be made much plumper, because this gives better tolerances. The rollers hold the oval sufficiently rigid that it may be plump without detriment.

The entry friction guides are rigidly clamped into the guide box. If a ragged end catches in the entry guides, it is not necessary to loosen the rollers when the entry guides are taken away to remove the ragged end.

As the groove in the entry guide is wide and the only resistance to be overcome is the rolling friction, it is easy to push in the oval. Even flakes and rather ragged ends usually pass the roller guides, which decreases scrap loss and increases the reliability. The roller guide not only makes possible the use of repeaters on smaller leader ovals but has also shown considerable advantages for breakdown ovals and heavier leader ovals, both when rolling with repeaters and when rolling by hand.

For the larger roller guides the mounting of the roller is made with taper roller bearings in the leaf spring, Figure 27. Here the shaft is revolving and is located by left- and right-hand screws, respectively. Washers are placed under the outer race of the taper roller bearing to give a tight fit. Figure 28 shows the roller guides for 0.2 to 8-in. (5 to 210-mm) rounds.

The roller guide may be used not only for leader and breakdown ovals but also for rolling squares, hexagons and various other sections. For edging flat iron a different type of roller guide is generally used, because in this case it is desirable to get the rollers as close as possible to the center of the rolls. In this way sharp-cornered flat iron up to 3 x 8 in. (75 x 200 mm) has been rolled.

It is almost general practice nowadays to use a rest-bar profile as in Figure 26, to fasten roller guides, as the guides can be advanced toward the rolls and secured with an easily accessible bolt without lateral movement during the tightening. A proposal for standardizing the rest-bar profiles has been prepared.

As for breakdown ovals and leader ovals up to 1 ¼ in. (30 mm) rounds the grooves in the entry guides, Figure 29, are always made with the same radius as that of the oval, but the opeining is made 0.08 to 0.12 in. (2 to 3 mm) larger than the thickness of the oval for 0.2-in. (5-mm) round and is increased gradually to about ⅝ in. (16 mm) for 6-in. (150-mm) round.

If the groove in the entry guide had been made with larger radius than the oval, it would have been more difficult for the oval to enter the grooves of the rollers. With heavier sizes, a larger gap is needed in the vertical direction for an easy entering in case the front end has been bent by the transfers or otherwise. The entry guide groove is therefore made with about 10 per cent larger radius than the oval. Previously the grooves in the entry guides were made with a smaller gap thus enabling the straightening of a bent oval. This was especially made to straighten the bend caused by the throw-out from the repeater for 5/16 to ⅝-in. (8 to 16-mm) rounds of hard steel qualities, and sometimes two roller guides in series were used for the same reason.

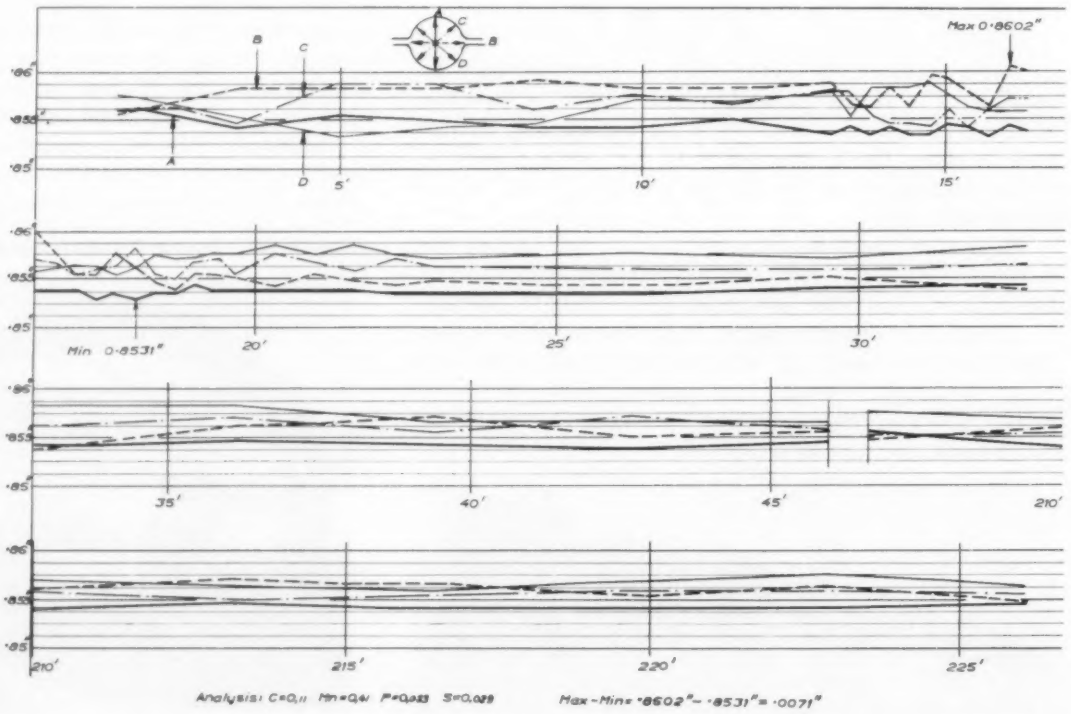


Figure 31 — Size variations on a bar of bolt iron 0.82 in. round from 440-lb billet rolled in the small-section train by means of repeater with straightening rollers between the repeater and the entry guide. The variations caused by the throwout may be seen to lie between 13 and 19 ft. Maximum is 0.8602 in., minimum is 0.8531 in. = 0.0071 in. difference.

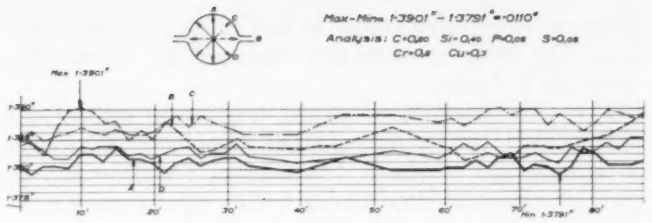


Figure 32 — Size variation on a bar of bolt iron 1.38 in. round from 585-lb billet rolled in the medium-section train with repeater and straightening rollers. Maximum is 1.3901 in., minimum is 1.3791 in. = 0.0110 in. difference.

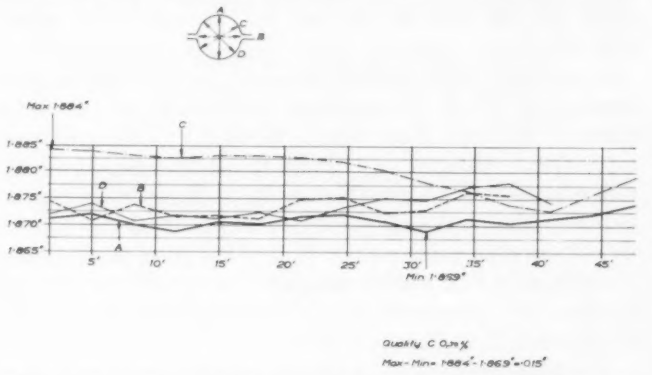


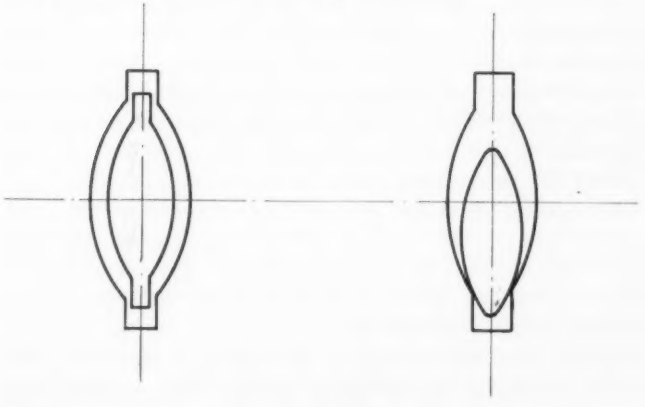
Figure 33 — Size variation on a bar 1.88 in. from 450-lb billet rolled in the medium-section train with repeater and straightening rollers. Maximum size is 1.884 in., and minimum is 1.869 in. = 0.015 in. difference.

The entry guide grooves are generally ground by means of devices as in Figure 30.

Nowadays, entry guide tubes from repeaters to roller guides with straightening rolls, Figure 23, are more generally used, and in such cases the entry guides are made with an extended funnel-shaped opening, so that the rolled stock does not touch the entry guides after the first end has been gripped by the rolls. This is of great importance when rolling adhesive material, e.g., stainless steel. The straightening rollers are set so close that there is hardly room for a straight oval. In such a way material up to 2-in. diam with a carbon percentage of 0.35 has been rolled with good tolerances. Figures 31, 32 and 33 illustrate that for hard steels straightening rollers should be used for larger rounds than $\frac{5}{16}$ in.

The entry guides are further provided with an additional groove to make room for an overfilled oval, e.g., caused by pipe, segregations, flakes or ragged ends.

Figure 34 — The entry guides are made with an additional groove to make room for an overfilled oval, but it must not be so large that the oval could get stuck.



It is important that the thickness of that groove is fitted for the greatest clearance between the rolls to make space enough for an overfill (Figure 34). However, the groove may not be made so large that the first end of the oval may get stuck there.

White cast iron is generally used for entry guides when rolling rounds up to about $\frac{3}{4}$ in. (19 mm), and for the larger sizes grey cast iron is used, and sometimes also ductile iron or cast steel for the largest sizes of each roller guide size, where the entry guides get thin and relatively weak for overload due to a bent bar, a split end or a knuckled end. Often a larger roller guide ought to be used, especially when rolling hard steel qualities.

For larger rounds, introduced by means of roller tables, a funnel-shaped guide in front of the roller guide

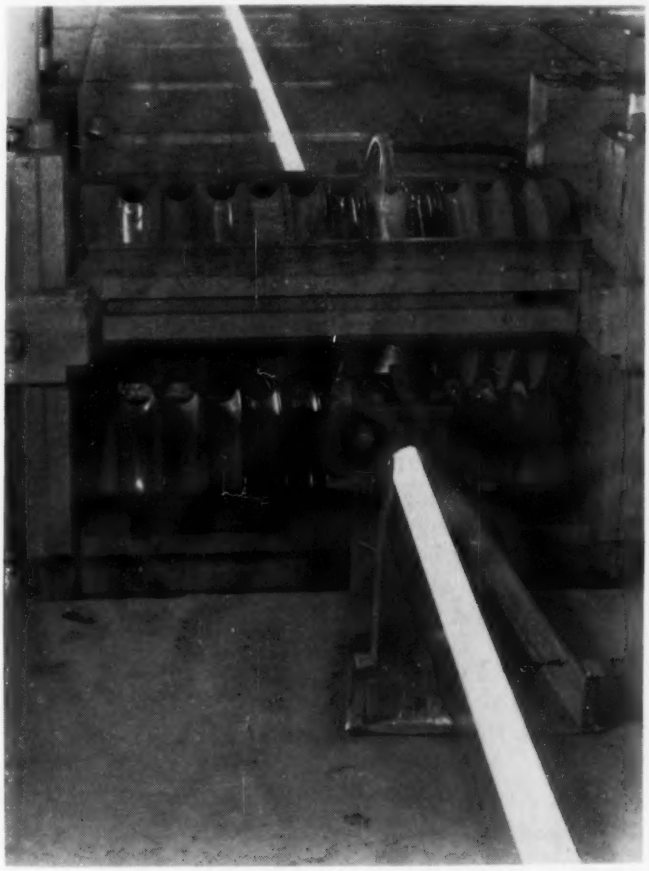
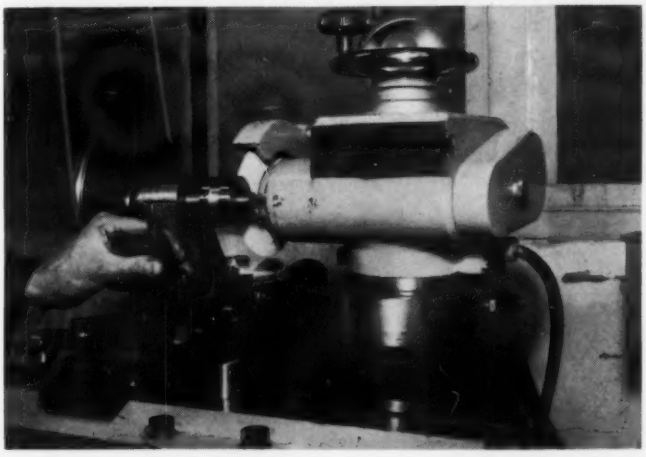


Figure 35 — For larger rounds, introduced by means of roller tables, a funnel-shaped guide in front of the roller guide and fastened in the locating hole is required.

Figure 36 — Device is used for redressing the roller grooves.



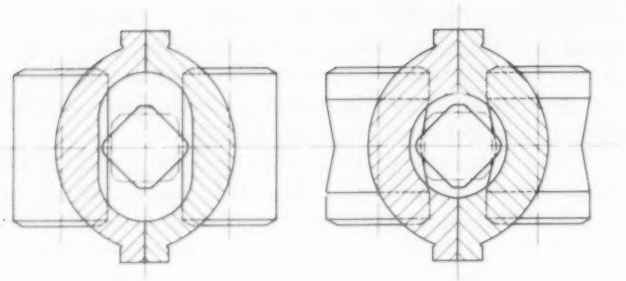


Figure 37 — The entry guides for squares ought to be made with a round groove and with diamond-shaped grooves in the rollers to obtain the best guiding conditions.

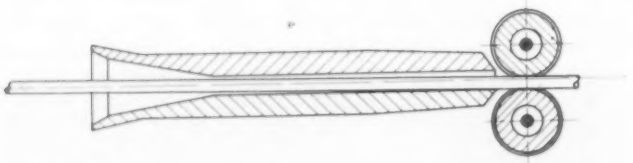


Figure 38 — Sometimes it happens that the rollers are positioned too much off center causing friction against the entry guides and the front end can get stuck.

and fastened in the locating hole is required, Figure 35.

The rollers for the leader oval have exactly the same radius as the oval, but sometimes, especially for large sizes, V-grooved rollers with an angle of about 124 degrees are used. V-grooves have the advantage that they may be used for a larger size range, but when regrinding the grooves of the hard rollers, more material has to be removed. The radius-shaped grooves require only a little grinding to get a clean surface. For high-grade steel radius-grinding must be used to get a low surface pressure between the roller and the oval. It will be easier to avoid damage to the rolled stock, and the groove is not worn out so rapidly. Even when using radius-shaped grooves, rollers having small holes or grey spots had to be rejected, due to the fact that they cause small protuberances on the oval, which will be rolled in in the finishing pass. To make it possible for the rollers to keep the oval steady, a certain contact

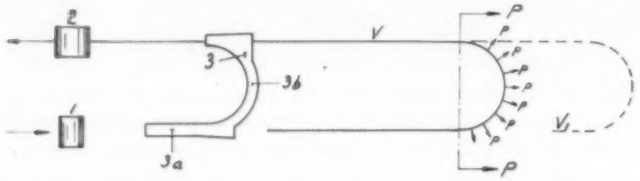


Figure 39 — When the rod has left the first stand, the centrifugal force throws out the tail end of the rod, producing a whip end.

Figure 40 — The wire-rod trains for the highest speeds are placed farthest away from the reels and cooling bed in the combined rolling mills.

pressure is required which in fact gives a small reduction. The roller grooves are redressed by means of a device as in Figure 36.

For thin breakdown ovals, ungrooved rollers are always used, but for plump breakdown ovals, V-grooves with an angle of about 144 degrees are necessary to prevent the oval from tilting in the square groove.

It is not necessary that the rollers are in contact with the oval when the bar runs smoothly. When using V-grooved or radius-grooved rollers, it is important that the entry guide grooves are not made too wide, as in this case the breakdown oval front-end may get stuck at the top or the bottom between the roller grooves.

Nowadays, roller guides are used even for the largest breakdown ovals in roughing mills with repeaters in spite of the fact that simple friction guides could be used there without any great disadvantage. If using roller guides it is possible to have greater clearance between the oval and the entry guides and the rollers do not need to press on the oval. This gives more space for pipe and flakes with smaller risk of cobbles. Owing to this, it is profitable to use roller guides also in the roughing mill on the oval side.

For high-grade steel, hitherto almost only white cast iron has been used for rollers up to about 1 in. (25 mm) diam. Unfortunately, it has not been possible to use this material for larger sizes due to machining difficulties, and for that reason steel of various alloys has been used. Rollers of tungsten carbide have been tested for leader ovals for No. 5 gage (5.59 mm), but so far after about two years' operation there are no definite, but promising results. Stellite-covered rollers are to a certain extent used for merchant bars. Steel with 13 per cent Cr and 2 per cent C is also used. Almost all kinds of material have been tried, but it is impossible to get a clear picture of the varying results. Having tried other materials, many rolling mills have gone back to white cast iron.

The most troublesome problem has been the wear of the bearings in the smallest roller guides when introduced in high production continuous rolling mills. Oil mist lubrication is necessary in such a case, but new experiments have to be made to increase the life time of the bearings. Until good results are obtained, roller guide No. 20 may be used down to 0.2 in. (5 mm) diam. On the whole, a larger roller guide should be used if needed for raising the strength of the entry guides or the life time of the rollers.

For squares, entry guides and rollers similar to Figure 37 (left) have hitherto been used.

The entry guide groove should be wide enough for the square to enter diagonally. The rollers are made ungrooved and are set to a somewhat smaller play than the diagonal dimension of the square. If the square enters diagonally, the guide-roller rolls the edges of the square to a certain extent at the same time as the rollers tilt the square to the flat position. The difference between the diagonal and the side dimensions are not too great. On the 1.42-in. (36-mm) side, the diagonal is 1.81-in. (46-mm). In a roughing mill the square grooves may be set a little inclined so that the square enters in the flat position.

From the beginning the leaf springs of the square roller guide were designed considerably thinner and

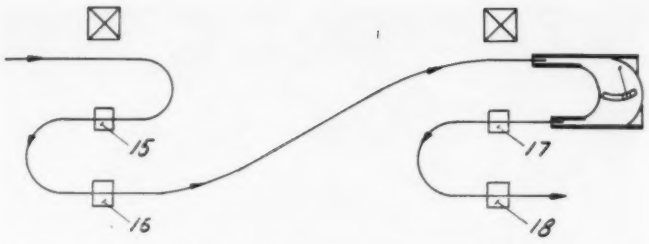


Figure 41 — When the rod leaves stand 16 its tail end is subject over a long distance to an acceleration by the centrifugal force from the loop. It is more difficult, therefore, to avoid whip ends than when rolling as shown in Figure 40.

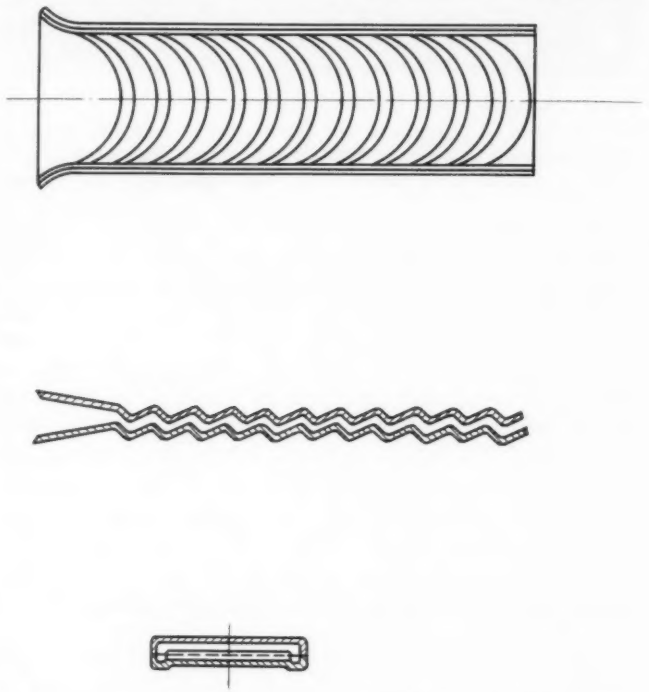


Figure 42 — The principle of the whip channel. When the tail end has left the preceding stand the loop tends to grow violently, but this tendency is counteracted by its bumping alternately against the upper and lower semi-circular flanges, in this way avoiding whip ends.

softer, so that the guide-roller gap corresponded to the square side, and if the square entered diagonally the rollers could yield sufficiently. It happened sometimes that these roller guides were also used for leader ovals with bad results, and for that reason that method was rejected.

It is of course better to make the guides as in Figure 37 (right). If the square enters diagonally, the corners need not be rolled down so much by the guide-rollers, and if it enters in a flat position, the guiding will also be excellent. A roller guide for the square gives better guiding than a friction guide, which is important when rolling with repeaters, as otherwise the front end of the square will enter on one side of the oval groove and the oval will get bent sideways, making the passage of the oval through the oval entry guide more difficult. Most of the cobbles previously received in the oval repeaters were caused by the square side.

For setting the guide rollers to a suitable pressure and the right height, trial bars of all passes of ovals and squares for each rolled size must be available in the roll changing shop as well as in the rolling mill. The trial bars in the rolling mill should be provided with welded-on offsets enabling control of the setting of the guide rollers in relation to the entry guides without stopping the mill motors. Owing to careless setting it happens sometimes that the rollers are screwed too much in one direction, so that the oval will be pressed against one entry guide and get stuck, Figure 38.

Nowadays, roller guides are used when rolling with repeaters on the oval side as well as on the square side, except in the special cases where there is not sufficient room for the roller guides.

WHIP CHANNELS

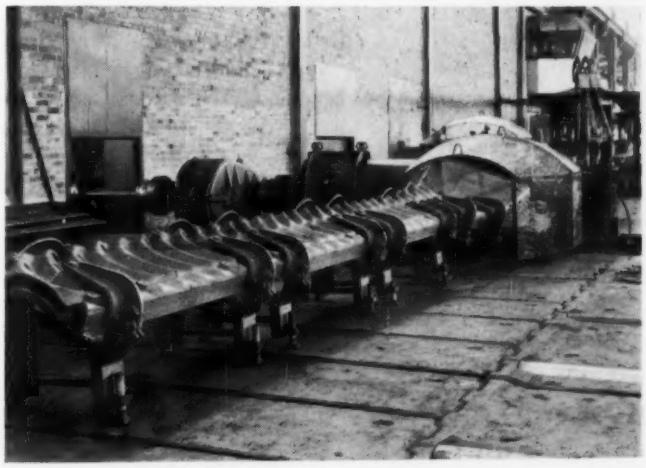
When rolling with repeaters at speeds of more than about 1700 fpm (8 to 9 meters per sec) the centrifugal force causes the same phenomenon on the tail end of the rod as when a whip is cracked. The doubled back ends or pig-tails stick to the roller guide and the rod is snatched away, so that the whip end remains in the entry guides, preventing the following rod from entering and thus cobbling it. As the centrifugal force is proportional to the square of the speed, the difficulties increase rapidly with a greater speed, Figure 39. After having passed the repeater, the front end of a rod throws out on the straight part 3a and over the outer edge 3b of the repeater 3. Then the rod smoothly runs out in a slowly increasing loop depending on the difference of the roll diameters in stands 1 and 2 and the coefficient of reduction.

If the speed of the rod is v fpm, there is a stress S in the rod of $S = \rho v^2/9640$ psi, where ρ = weight, lb per cu in. This formula is analogous to that of the stress in a flywheel. For $\rho = 0.28$ for iron and $v = 4000$ fpm, $S = (0.28 \times 4000^2)/9640 = 465$ psi. For 0.2-in. (5-mm) square section, $P = 465 \times 0.2^2 = 18.6$ lb.

The tensile force is thus considerable, and when the back end has left stand 1 the loop grows violently to the position shown by the broken line, at the same time as the back end rapidly accelerates to the speed v_1, which is much higher than v. The longer the loop when its tail end is released from the preceding stand, the greater will be the final velocity, and it becomes more difficult to avoid whipping of the ends.

This is one of the reasons for placing the wire-rod trains for the highest speeds in the opposite direction to the normal flow, and as far as possible away from the small-section train, Figure 2. A comparison of these

Figure 43 — An oval repeater is used with a whip channel for a wire-rod train in Hagfors Steel Works, Uddeholms AB.



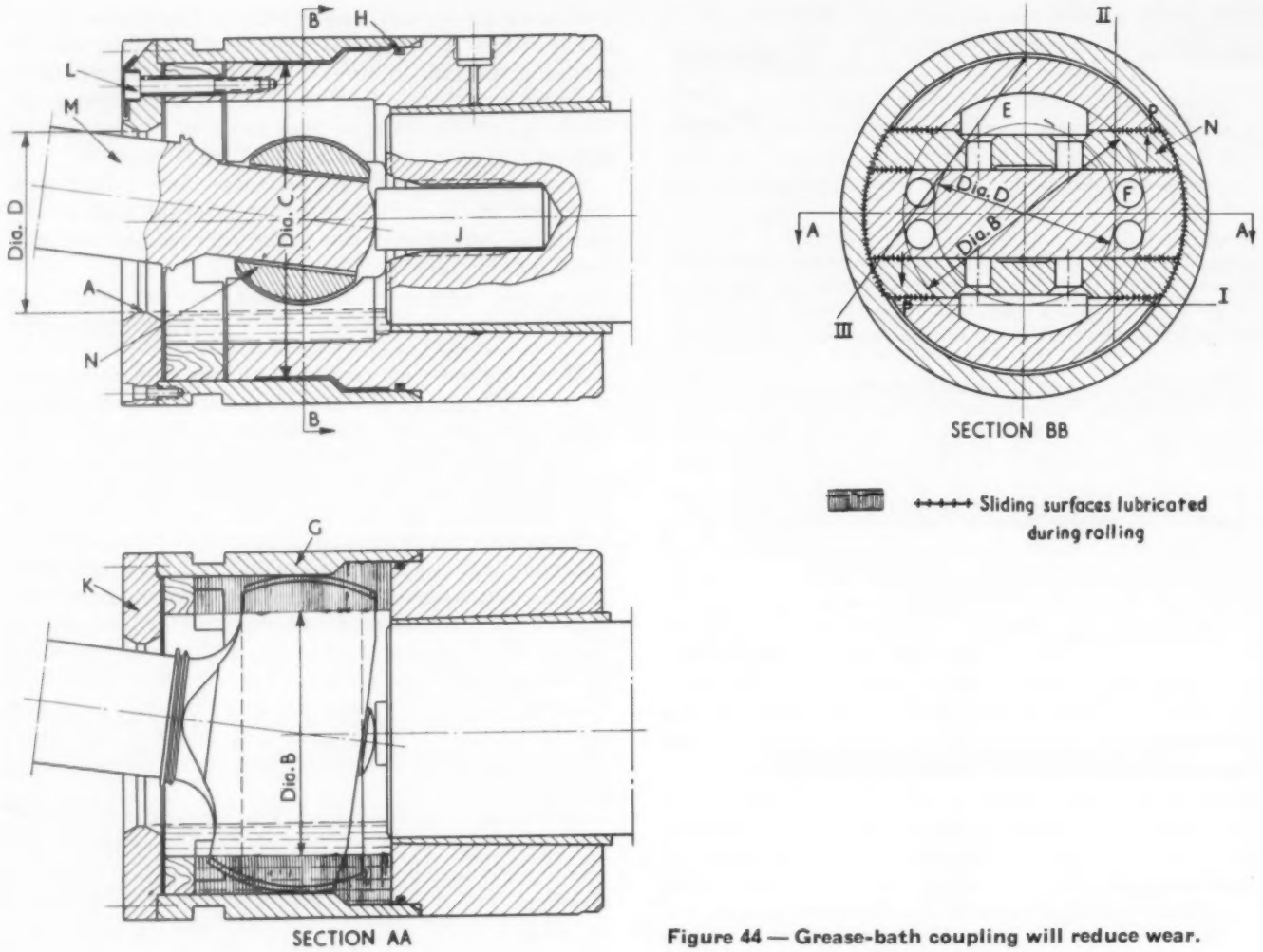


Figure 44 — Grease-bath coupling will reduce wear.

conditions is shown in Figure 40 and in Figure 41. In the latter case, the bar is accelerated the whole way from stand 16 to the loop-regulating repeater. At speeds of about 4000 fpm (20 meters per sec) the bar may throw itself out of the repeater immediately after the back end has left stand 16. It is thus possible to roll at higher speed according to Figure 40 without being disturbed by whip ends.

It is most important to prevent the violent acceleration of the back end, which can be carried out by means of a whip channel, Figure 42. The rod strikes alternately against the upper and the lower semicircular flanges. The whip channel does not cause any considerable resistance before the rod has left the preceding stand, and the loop, because of its centrifugal force, tends to grow. Figure 24 shows a loop-regulating repeater for squares which is assembled together with a whip channel. Figure 43 shows an oval repeater with an accessory whip channel. With these devices it is possible to roll at 4300 fpm (22 meters per sec) and in certain cases up to 4800 fpm (24 meters per sec) finishing speed on 0.2 and ¼-in. (5 and 6-mm) wire rod. No opportunity has yet presented itself for testing repeater and whip channels at higher speeds.

GREASE BATH COUPLINGS

Figure 44 shows the principle of a so-called grease bath coupling, which has been in practical use since the latter part of 1950. If properly maintained, it appears that the sliding surfaces will show no appreciable wear.

The principle is simply that when the mill is not in operation the grease should not flow over the outer edge A in, for example, level I, II or III, depending on the position in which the coupling stops. When the mill rotates, the grease is thrown out of diameter B and fills all spaces between diameters B and C (hatched areas). The cavities outside diameter B are made as small as possible. Between diameters B and D, on the other hand, cavities as large as possible are made. Oil con-

Figure 45 — Man is assembling grease-bath coupling.

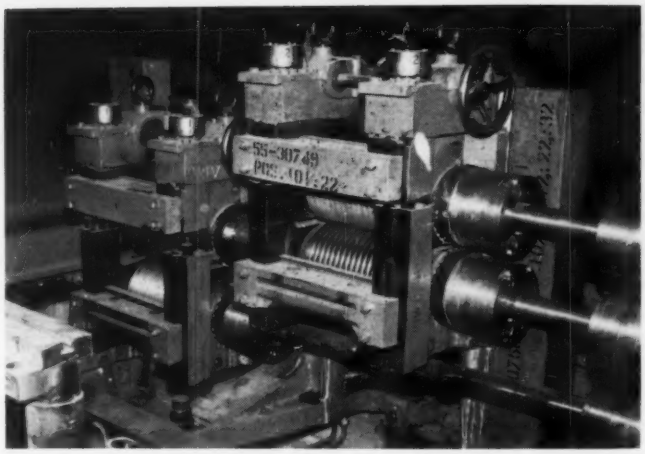


Figure 46 — For rolling plump leader ovals in an alternating 2-high mill, a fairly large inclination is needed for reliable working. Note the small distance between the stands.

tainers E are situated in the coupling head and cavities F are drilled along the flat end of the spindle to make the oil containers as large as possible with the mill at rest. The grease volume of the sector under edge A at rest is thus sufficient to fill out all cavities outside diameter B when in rotation. As a rule, a rather viscous grease is used, in which case diameter B can be chosen somewhat smaller than the theoretically correct one, because all the grease does not run down in the lower sector at standstills.

The flat ends of the coupling spindle are made with a spherical surface against the outer ring G, and this centralizes the coupling spindle and absorbs the forces P which strive to pry apart the jaw of the coupling head, when torque is transferred. The coupling spindle is fixed longitudinally by a wooden or bronze pin J, which is pushed into the hole of the roll neck and which disintegrates in case of roll breakage.

The ring G with the flanged end K is, from the beginning, mounted on the coupling spindle and is always fixed there. On installation the lower slide metal N is inserted at the same time as spindle M. Also see Figure 45. The upper slide metal N is inserted and rings G and ends K are pushed on to the coupling head. By means of screws L the ring is drawn to its final position and is locked by a safety plate ring, which is bent into the recess.

The assembly and dismounting of the coupling heads on the roll neck is nowadays done with the pressure-oil method. As the coupling heads are fixed on the rolls and are counterbalanced in the mill stand, the weight of the spindle is often so small that a spindle carrier may be unnecessary.

Trials have lately been started to divide the spindle and connect the halves with a spline sleeve in order to reduce the roll-changing time radically.

THREE-HIGH AND ALTERNATING TWO-HIGH MILL ROLL UNITS

As the repeaters for plump leader ovals, for sharp-cornered squares and certain other sections demand a fairly large slope to work reliably, a new design of alternating two-high stand has been made, Figure 46. The principle is that the roll units are lowered on ver-

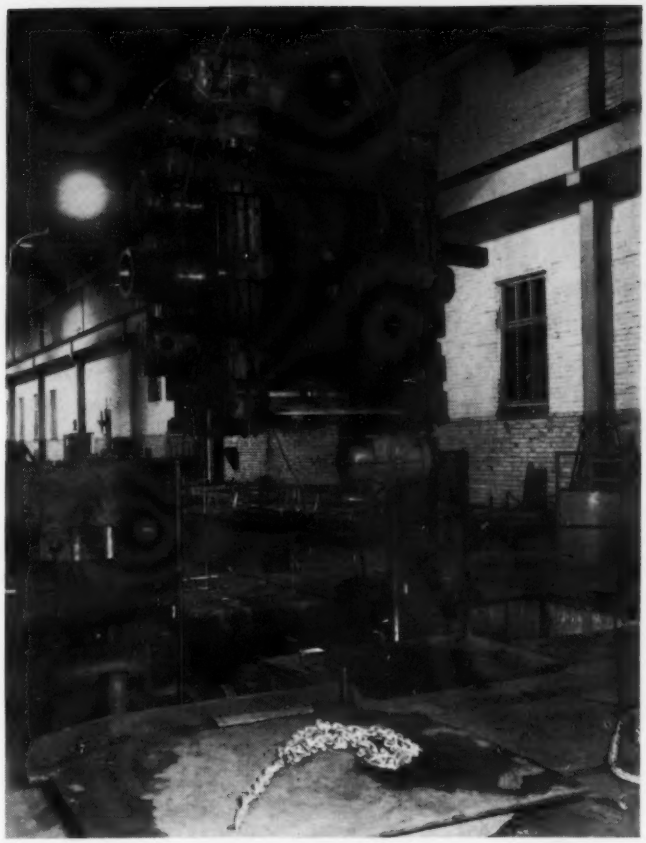
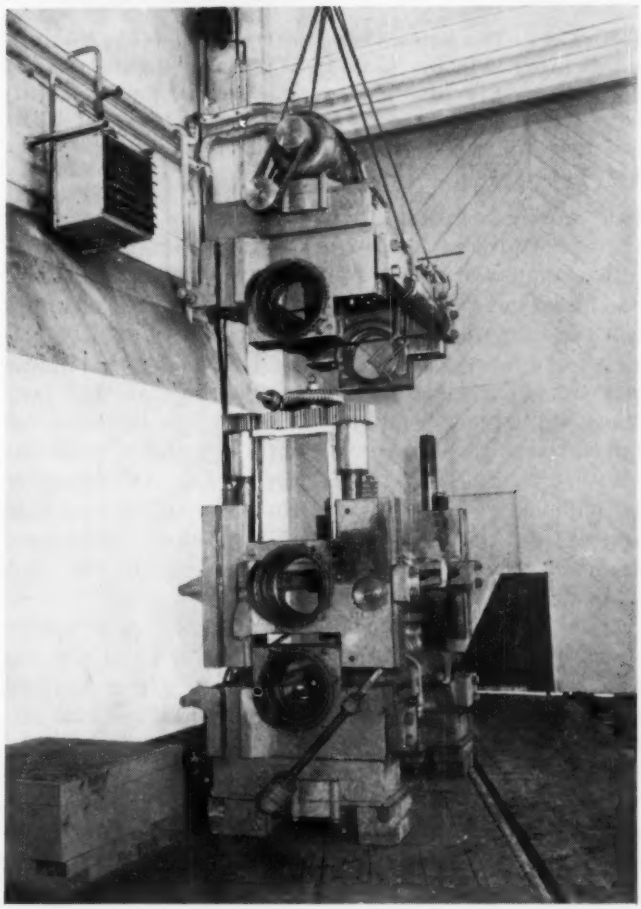


Figure 47 — A new 3-high roll unit (21.6 in. diam. x 49.2 in.) being lowered on to posts in a medium-section train at Söderfors Steel Works.

Figure 48 — Checking roll chocks and their accessories in the shop. The nuts and gears for the set-screws have been put on to show the design.



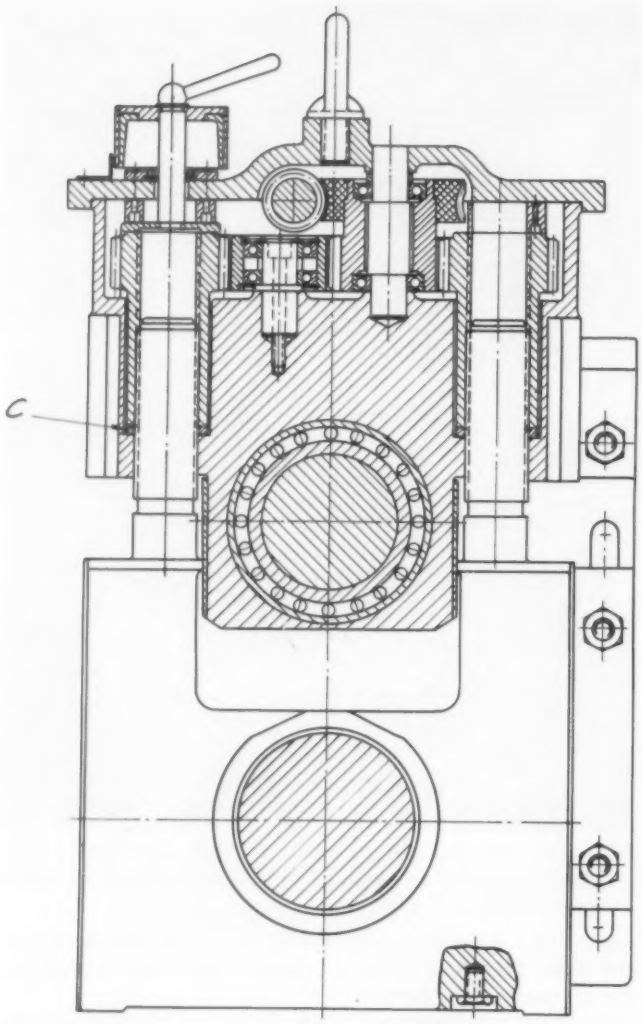


Figure 49 — The bottom roll chock has two set-screws upwards integral in the same steel casting. In the top roll chock there is for each screw a rotating nut and a ring (C) with a spherical upper surface and plane lower face. The roll pressure is transmitted in a strip around the roller bearings.

tical posts, Figure 47, which carry the roll unit. In the upper alternating two-high mill stand, the bottom roll rests on the offsets of the posts and the upper roll can be set independently. In the bottom stand the upper roll rests on the posts and the bottom roll can be elevated or lowered by setting. By this means the middle row is fixed vertically and carefully alined so that very short spline couplings can be used. The distance between the stands can consequently be reduced considerably, so that perfect inclination for the oval repeaters is achieved, Figure 21. As the alternating two-high stands of this design showed important advantages even in other respects also, a three-high roll unit as in Figure 48 was developed.

The middle roll chocks are provided with guides upwards and downwards to fit the chocks of the top and bottom rolls until the roll unit has been lowered on the supporting posts. Every roll chock has two set-screws upwards and two downwards, integral in the same steel casting as the chock of the middle roll. In the top and bottom roll chocks there is for each screw a rotating nut, which, by cylindrical gears and worm gears, is driven when the clearance between the rolls is being adjusted, Figure 49, either by hand or by motor. Under the mill nut, the lower surface of which is spherical, a corresponding ring C with a plane bottom is placed. The mill nut is commonly held radially only by the threads of the screw, but it can be supported by sliding surfaces if required, to set the rolls against higher roll pressure. One mill nut in every chock is provided with a pointer drum, showing the clearance between the rolls. This pointer drum can at any time be provided with a special drum with dovetailed slot and runners, Figure 50. The latter operate the limit switch, which on automatic screwdown stops the motor. Such drums can be preset and are easy to replace when altering the thickness of the rolled bar. When automatic screwdown is used, the rolls can be tightened gradually before each pass until the smallest clearance is reached. The rolls then have to be opened to the first pass automatically to be ready for the next bar. The top roll is set while the bar is rolled in the bottom roll and vice versa. The top roll is counterbalanced in relation to the middle roll generally by means of stacks of cup springs.

The bearing posts are provided with offsets on which the middle roll chocks rest. The middle roll chock is thus fixed vertically and also axially, and the top roll as well as the bottom roll is adjustable in relation to the

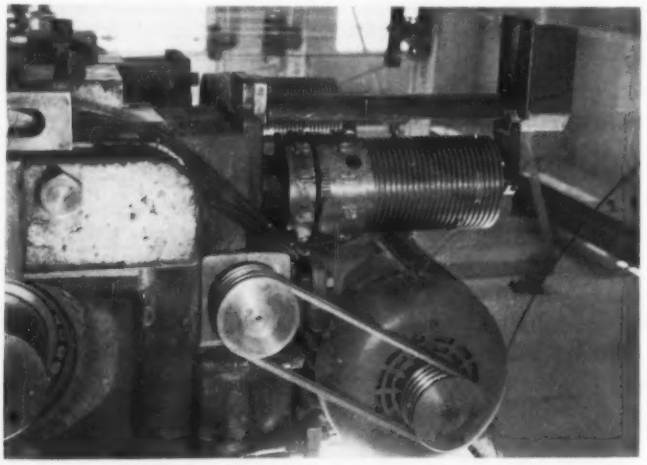
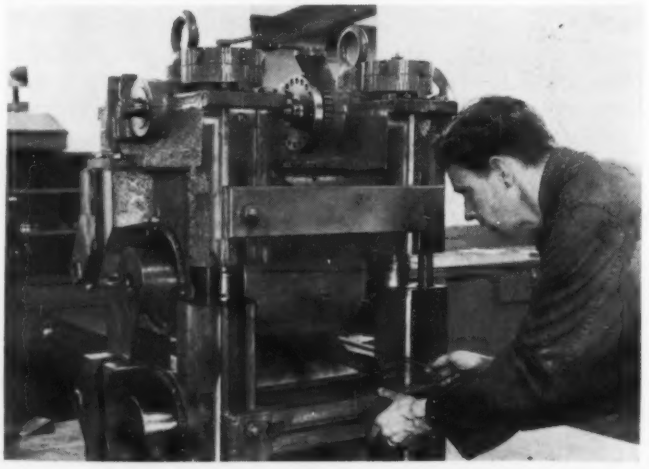


Figure 50 — Pointer drum has automatic roll-setting device.

Figure 51 — A ⅛-in. thickness gage is pressed between the rolls and the parallelism of the rolls at both ends of the barrel is checked with a 0.006-in. thinner feeler gage before the pointer drums are fixed in position. If set-screws are provided with roll-pressure gages, the pointer drums are set at a certain roll pressure.



middle roll. In three-high rolling mills, exchangeable washers (A) are used on the offsets, Figure 47, so that the whole roll unit can be placed at a suitably high level relative to the roller tables that is desirable in every case, considering the roll diameter, the groove depth and the clearance between the rolls. This is important for avoiding knuckled front ends on heavier bars. The bottom roll with chocks is suspended by the mill screws, and the weight of the bottom roll eliminates the clearance in the threads of the screws. To enable only one end of the roll to be adjusted for larger clearance than the other end, the shaft which connects the screwdown device is divided and provided with a clutch, Figure 51. The coupling has teeth and engages with a pitch of 0.0004 in. (0.01 mm). One outlet journal on the screwdown is provided with a pulley for driving with V-belts from the motor, Figure 50.

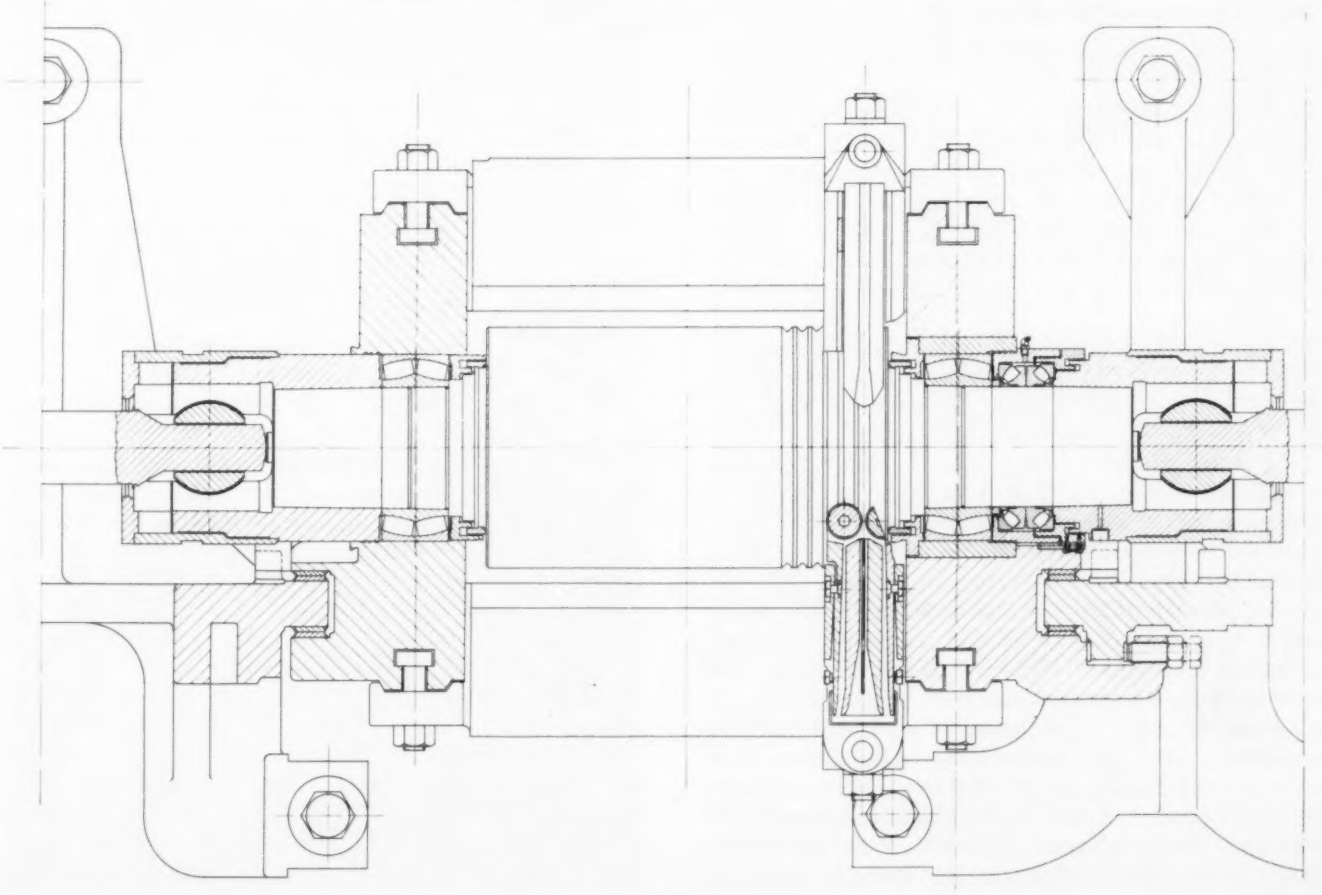
The rolls are provided with one spherical roller bearing for each roll neck, Figure 52. The roller bearings have tapered seats, and the bearings with their chocks are pressed onto the roll neck, to give a shrinkage fit. For dismounting the bearing with its chock the pressure-oil method is used. The roll chocks are held together as a unit by rest bars, cooling-water bars and sometimes idle bars. The bars hold the chocks at a certain fixed distance from each other and at the same time keep them as a stiff frame, so that the axial deflection will be as small as possible if there is axial pressure from the bar. The radial roller bearings are free axially in the chock. On this side the labyrinth seals are so made that the radial roller bearing and the labyrinth seal are pushed into the radial chock in case of roll breaks. Also the universal coupling head on the radial bearing side is thus displaced laterally in the case of a roll break. The axial movement in relation to the radial bearing chocks is somewhat greater than on previous roller bearing designs, so as to secure the greatest possible safety against damage occurring as a result of roll breaks.

The middle roll chocks are laterally firmly fixed in the post while the top and bottom roll chocks may be adjusted to correct axial position against the post as shown in Figure 52. They may either be tightened or locked with a clearance in relation to the post to allow screw setting between each pass. There are additional screws for correct axial adjustment of the rolls, Figure 45, in the roll changing shop.

As the rest bars are tightened to the roll chocks the guides follow the rolls when adjusted. Screwdown setting of the rolls between each pass is thus possible even when rolling in profiled grooves, and it is possible to incorporate both top and bottom delivery guides which follow their rolls when set or adjusted, thereby preventing the rolled bar from bending in any direction. In conventional stands the rest bars are tightened to the roll housing which gives rise to the necessity of adjusting the rest bar height, if the bottom roll is set in a three-high stand.

As the roll housing is eliminated and the roll chocks are narrow, the guides and cooling water pipes will be easily accessible, Figure 53. Special consideration has been given to reducing the deflections. In the new design the forces act as in a strip around the roller bearings, Figure 49. The resilient lengths have been reduced to a minimum, and at the same time all point and line contacts have been avoided; the only contact

Figure 52 — Section through a middle roll chock. The rolls are provided with a lateral thrust bearing.



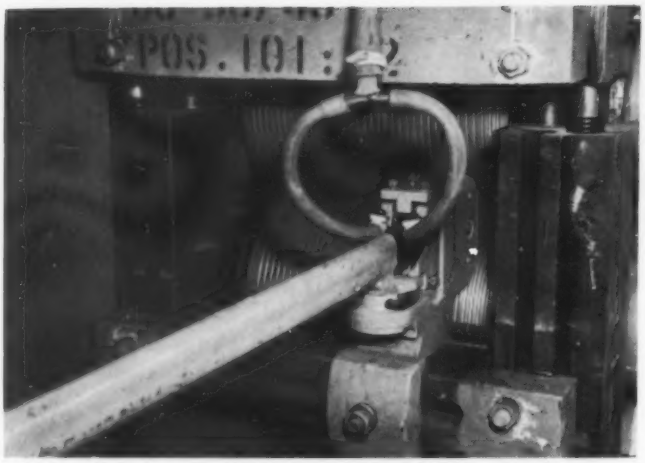


Figure 53 — As the roll chocks are machined close to the set-screws, the whole barrel length can generally be utilized.

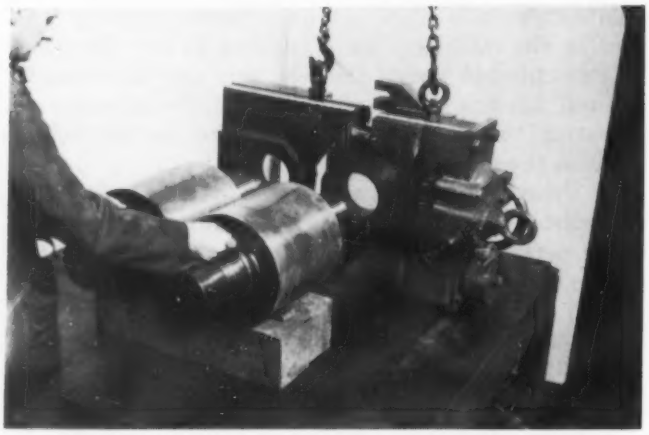


Figure 54 — Mounting new rolls in the roll-changing shop (9.45 to 14.2 in.diam x 15.2-in. rolls).

surfaces will be found in the threads and in both sides of the spacer.

The radial deflections in the new design seem to be of the order of one third of those in common stands of modern design, and all users who have installed these new stands agree that the tolerances of the finished steel are much better than before. Furthermore, the strippers are much better positioned, when the bar enters, against the roll groove than in the conventional mill stands.

The axial deflection is about equal to that of common stands with fabric bearings, but if spherical thrust bearings are installed, Figure 52, even the axial deflection is reduced to the order of one third.

To give the guides as much lateral space as possible the surfaces inside the chocks have been cut off as much as possible without detriment to the efficiency, Figure 53. As a consequence, more of the barrel of the roll can be used than in common designs. This is, however, most noticeable in wire-rod mills, where the outermost groove can be placed as near the barrel end as the strength of the outer flange permits. The center of the outer groove can thus be set $\frac{7}{16}$ in. (11 mm) from the barrel end for roller guides 12 and $1\frac{1}{4}$ in. (32 mm) for roller guides 30 in mills with 9.45 to 14.2 in. diam x 15.2 in. (240 to 360 mm diam x 385 mm) roll units. In conventional stands the barrel lengths are sometimes badly utilized. For example, the barrel length 15.2 in. (385 mm) in the new stand corresponds to that of 16.2 in. (410 mm) in the conventional wire-rod stand.

Since one roller bearing is used per roll neck, it can be placed close to the barrel end, greatly increasing the strength of the roll necks. As a result of these steps, with moderate barrel length, short roll neck to the center of the roller bearing, and round driving neck with the pressure-oil method for fastening the coupling head, the strength of the rolls has become satisfactory. Breaks in the roll neck are rare. The use of grease lubrication avoids corrosion fatigue in the roll neck recess. With fabric bearings there is undoubtedly a reduction in neck strength from this cause.

The rolls with their chocks, rest bars, guides and cooling-water pipes are assembled in special roll-changing shops, and thereafter the complete set of rolls with accessories and coupling heads is transported as a single unit to the mill and lowered onto the vertical posts, until the middle roll chock rests on the offsets of the posts. Thus stands are changed very rapidly and test rolling can be reduced to a minimum, as adjustment has already been made in the roll-changing shop.

After ten years' effort the normal routine nowadays is to set up the roll unit with such perfect roll adjustment both radially and axially and with sufficiently exact adjustment of guides, repeater, etc., that rolling of trial bars for gaging is no longer needed. Rolling of first rate bars can be made immediately.

Owing to the small deflections normal tolerances are easily obtained from the first bar on.

The assembly of the roll units in the roll-changing shop is shown in Figure 54. The rolls are placed side by side, and the roll-chock unit for one side of the rolls is pushed onto them. The roller bearings and coupling heads are pressed onto the roll necks, Figure 55. The rest bars for the upper side are put in place and the rest bar height is adjusted and tightened. By means of a traveling crane the roll unit is turned to the upright position and the rest bars on the other side are adjusted with a rule, Figure 18, and tightened. The axial position of the rolls is adjusted, Figure 45, and the roll play is regulated according to Figure 51 with, for example, an $\frac{1}{8}$-in. thickness gage which is pressed between the rolls. A feeler gage 0.006 in. thinner is used to check in the barrel ends that the rolls are parallel, after which the pointer drums are fixed in correct position.

When the rolling mills are intended for small tonnages of each size, and especially when rolling alloy steel with narrow tolerances, it is necessary to know the roll pressure in order to set the rolls to the exactly correct clearance in advance. Strain gages may be incorporated in a hole of the mill screws and when necessary connected to recording devices. The bearing pressure can be read off during rolling, and when adjusting the pointer drum the thickness gage is inserted between the rolls, while the pressure is increased to a fixed roll pressure. It is possible to determine the exact roll setting by means of radial deflection curves for the mill stands and from the practical values of both the roll pressures and the wear of the roll grooves. However, it is very difficult to enforce these methods in practice.

The time required in the roll-changing shop, excluding the cleaning and dismantling of guides and cooling

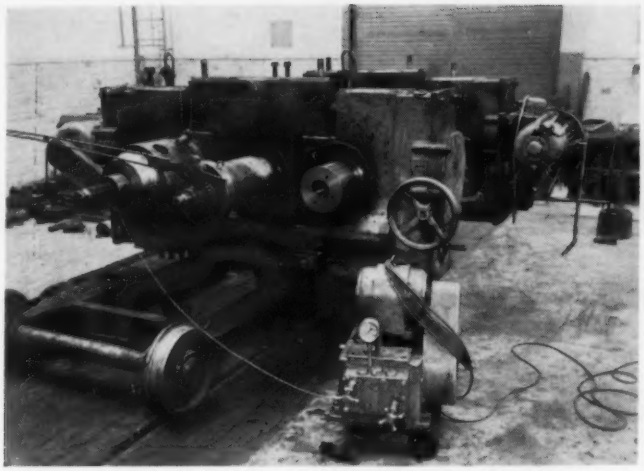
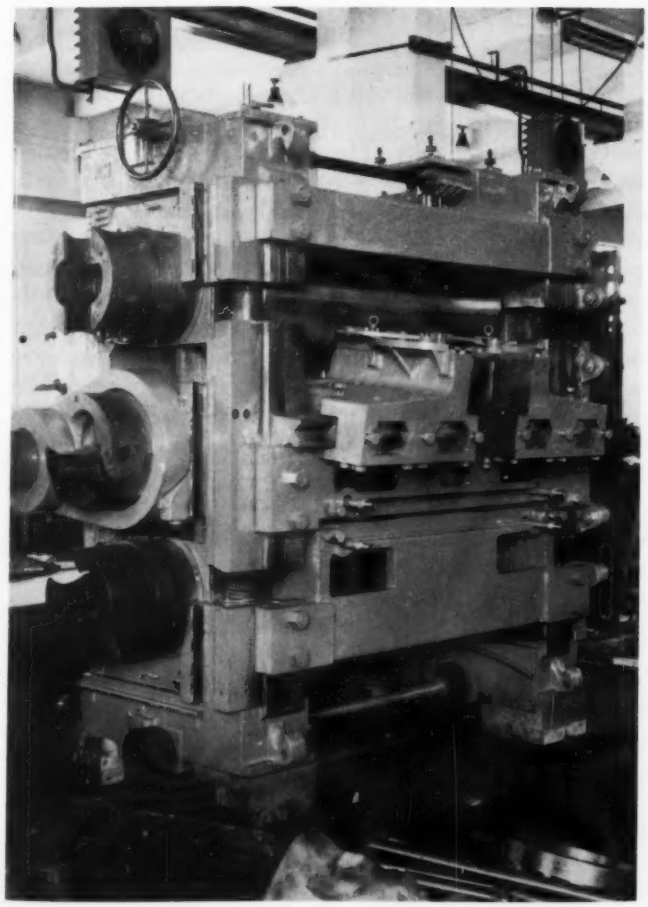


Figure 55 — When the roll-chock unit on one side has been put on its roll necks, the roller-bearings and the universal coupling heads are forced up the cone by the pressure-roller method.

water pipes, is about 6 hr for 19.3 to 21.6 in. diam x 49.2-in. (490 to 550-mm diam x 1250-mm) unit rolls and 45 minutes for 9.45 to 14.2-in. diam x 15.2-in. (240 to 360-mm diam x 385-mm) roll units. The time is reckoned from the moment when the roll units enter the shop until they leave it.

The weight of a three-high unit with 21.6-in. diam x 59-in. (550-mm diam x 1500-mm) rolls and universal coupling heads is 22.5 tons, which is about half the weight of a complete roll stand of conventional design.

Figure 56 — The upper entry guides are synchronized with the vertical roll set-screws and guided by means of rollers on the rest bars.



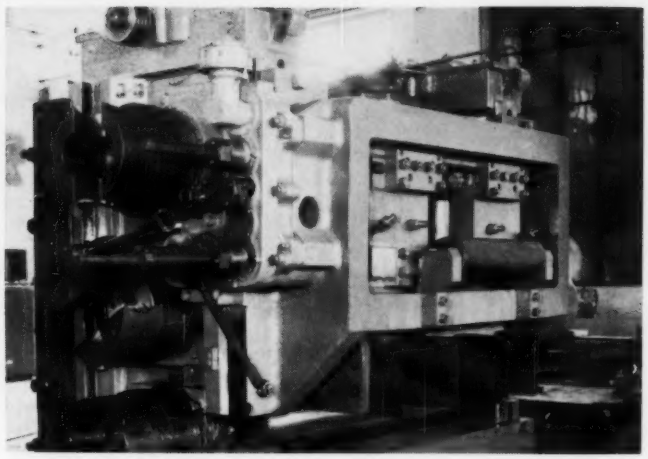


Figure 57 — On the middle roll chock a vertical roll unit is fixed. The vertical rolls are driven from the middle roll and the roil pressure is absorbed by three left- and right-hand screws.

In the beginning it was feared that the roll units might be damaged at roll breaks. During the 13 years that the design has been in practical use, two roll chocks have been discarded because of the fact that the mill could not be stopped until 15 minutes after the roll break. On two occasions three mill screws have been broken. The stands are now used as top and bottom units and as yet no new mill screws have been welded on.

In other cases of roll breaks, tightening rings and sometimes roller bearings have had to be replaced. At present there are 256 stands 9.4/14.2 in., 72 stands 11.4/16.5 in. and 83 stands 19.21/21.6 in. in operation.

In conventional stands the wear plates in the housing windows and on the roll chocks need to be replaced every third year. Since this new design is suspended unilaterally on the posts no rubbing will occur between the contact surfaces. Hitherto no wear plates have been replaced except in one exceptional case, despite the fact that some of these stands have been used as universal mill stands and the rolls have been set by screwdown motor between each pass. Nor has any damage occurred to the attachment surfaces of the rest bars, because there has rarely been any need for elevating or lowering them in the mill. It could be expected that these stands with carefully machined surfaces would rapidly be destroyed by the old sledge and bending-bar routine, but since the roll-changing is effected in quiet and clean shops with good illumination and proper tools, it seems as if the crew instinctively want to take good care of the stands and of all the accessories.

The cleaning of the stands takes a relatively long time, so that nowadays specially equipped cleaning compartments with steam and cleaning pits are used. A normal cleaning of a wire-rod roll unit takes about half an hour and of a medium-section roll unit about one hour.

Sometimes fears are expressed that the stands are too light and some people are of the opinion that mill stands ought to have a heavy mass. The principle in this new design has been that the stands should be as light as possible, enabling easy and rapid treatment at roll changes, but with strength and rigidity

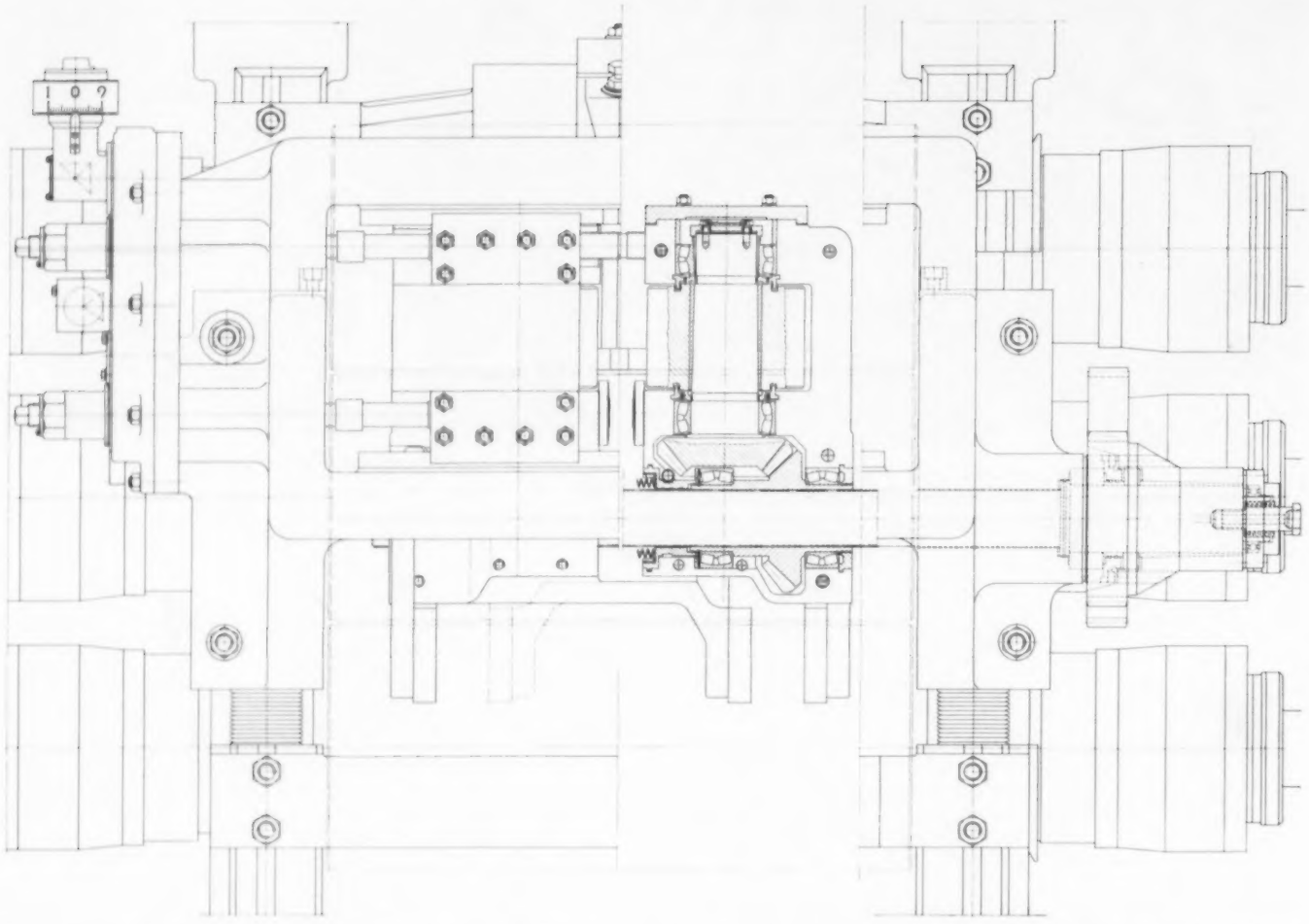


Figure 58 — Section through the vertical roll unit. The bottom entry guides are integral with the vertical roll chocks and follow them when set.

against roll pressure and other forces that can occur during rolling, not less than that of conventional stands. For instance, the small section and wire-rod stands with 9.4 to 14.2 x 15.2 in. (240 to 360 x 385-mm) steel rolls have been tested with a roll pressure of 400 tons in the barrel center without any plastic deformations. The roller bearings do not stand such high roll pressures without reducing the running accuracy. Chilled cast iron rolls usually will break at a roll neck pressure of 140 tons.

The lateral forces are transmitted to the supporting posts which are wide, Figure 47, and well adapted to take up these forces without deflections, and thus are consequently much better than the conventional mill housings. The normal foundation prism-beams running the whole length of the train, are in this case replaced by individual square plates, Figure 46. Every supporting post is tightened to the foundation by means of three long screws, so that the forces will be directly transmitted to the anchor plates in the foundation.

In the direction of the rolled stock the supporting posts may yield a little, which can be observed when a bar of 3500 lb (1600 kg) weight is gripped by the rolls in a medium-section train. Nevertheless, they can take up about 200 tons in this direction which will never occur even in the case of heavy bars entering against a tilting table. The supporting posts for the 9.4 to 14.5 in. diam x 15.2-in. stands are made capable of stretching to rupture point, an 1⅛ in. square bar of 0.50 per cent carbon content.

UNIVERSAL ROLLING MILLS

Adding vertical rolls to a three-high stand or to the upper stand in an alternating two-high mill gives a universal rolling mill. The design is seen in Figures 56 and 57, which show a 20.5 to 21.6-in. diam x 49.3-in. (520 to 550-mm diam x 1500-mm) three-high universal mill. The vertical rolls with chocks and bevel gears are supported and guided on rest bars, which are tightened with bolts on the chocks of the middle horizontal roll. The vertical rolls run in spherical roller bearings on both ends of the roll, Figure 58, and are set by three right- and left-hand screws, connected to a gear box outside the middle horizontal roll chock. The vertical rolls are adjusted by a ratchet wrench or through a vertical spline shaft from a motor.

The torque to the vertical rolls is usually taken from a coupling head of the horizontal middle roll via cylindrical gears, Figure 58, to an intermediate spline shaft. From this shaft the torque is transmitted by bevel gears to the vertical rolls. The vertical rolls incline a little outwards so that the bar coming from the horizontal rolls will be fed against the bottom guide rollers, Figure 59, in the vertical roll housings, owing to the inclination of the vertical rolls. This design is made to produce a correct rectangular flat bar and has proved very efficient. At the same time, however, the vertical rolls are placed as close to the center-line of the horizontal rolls as possible, which gives a more accurate rectangular form. In front of the vertical rolls is fitted

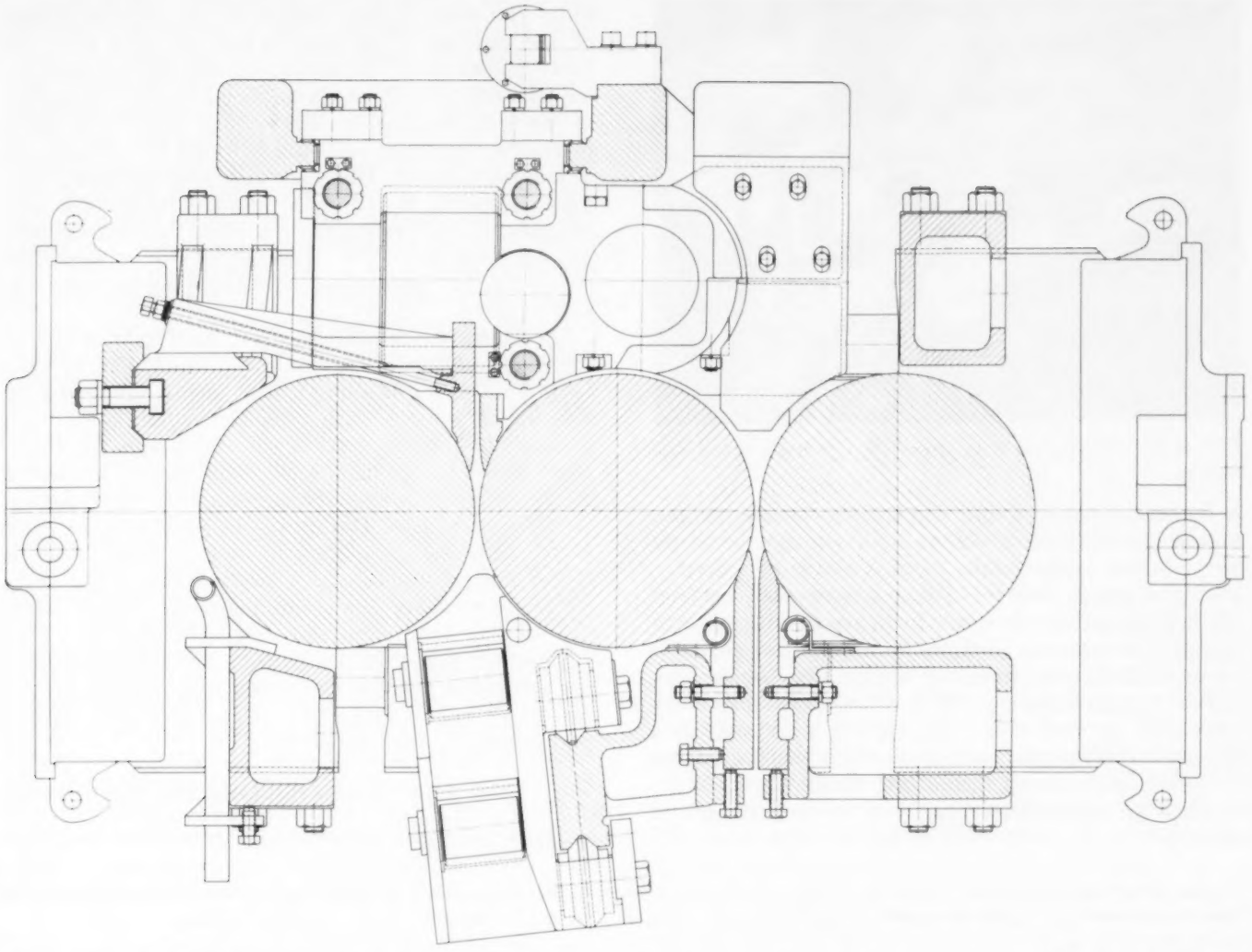
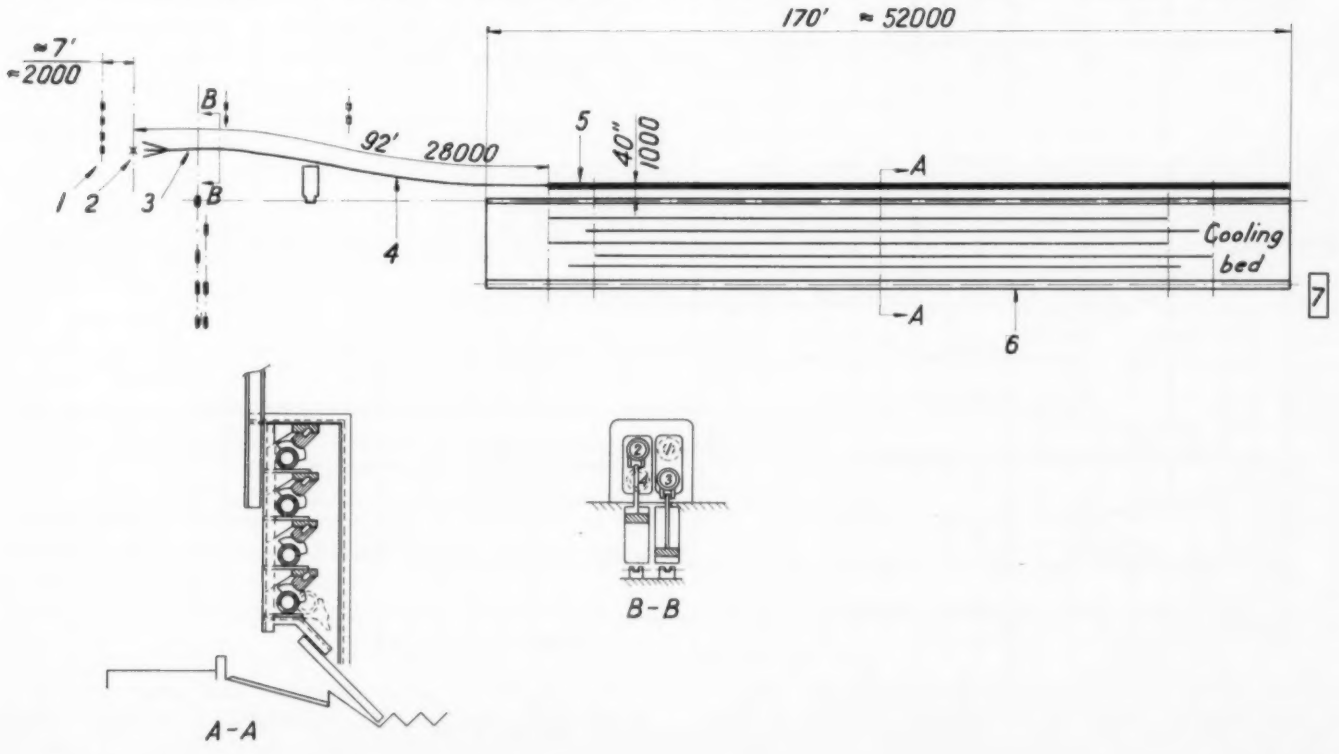


Figure 59 — Each stripper is fixed to the corresponding roll. Thus when setting the horizontal and the vertical rolls, the guides are also set without any additional adjustments.

Figure 60 — Layout and sections for the high-speed discharge to the cooling bed, at present operating at about 3000 fpm.



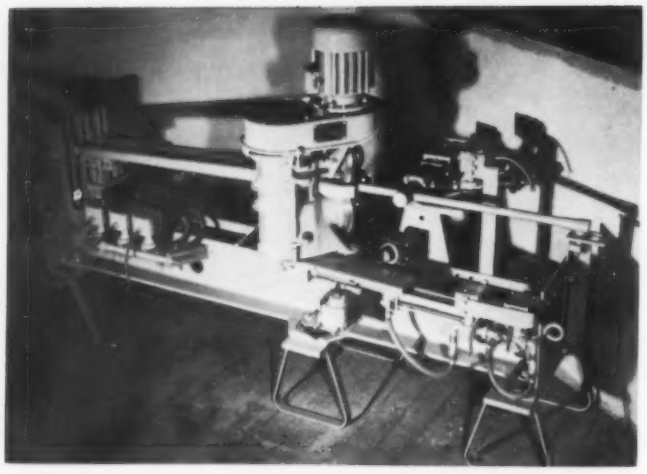


Figure 61 — Revolving disk shear for the high speed discharge.

a bottom delivery guide, Figure 59, resting on the chocks of the vertical rolls, and also an upper delivery guide, which is secured in the exit rest bar of the top roll. The upper delivery guide follows the top roll when adjusted. Owing to the inclination of the vertical rolls, the exit guides need not be adjusted so narrowly as on conventional universal mills. The bar is kept steadily pressed against the bottom guide rollers between the vertical rolls. The delivery guide including the guide rollers need not be changed for varying widths.

Owing to the small distance from the vertical rolls to the horizontal rolls, the bar must be carefully guided sideways on the entry side in front of the horizontal rolls. The entry guides, Figure 56, are fixed to rollers on the rest bar of the middle roll. In order that the entry guides may follow the vertical rolls exactly on adjustment, a shaft has been placed on the set-screws of the gear housing of the vertical rolls. This shaft drives the right- and left-hand screw for the adjustment of the entry guides. The entry guides are provided with guide rollers to facilitate the entrance of the bar and to prevent any binding effects, when the entry guides are narrowly set. The guide rollers have eccentric shafts for fine adjustment of the opening between the entry guides.

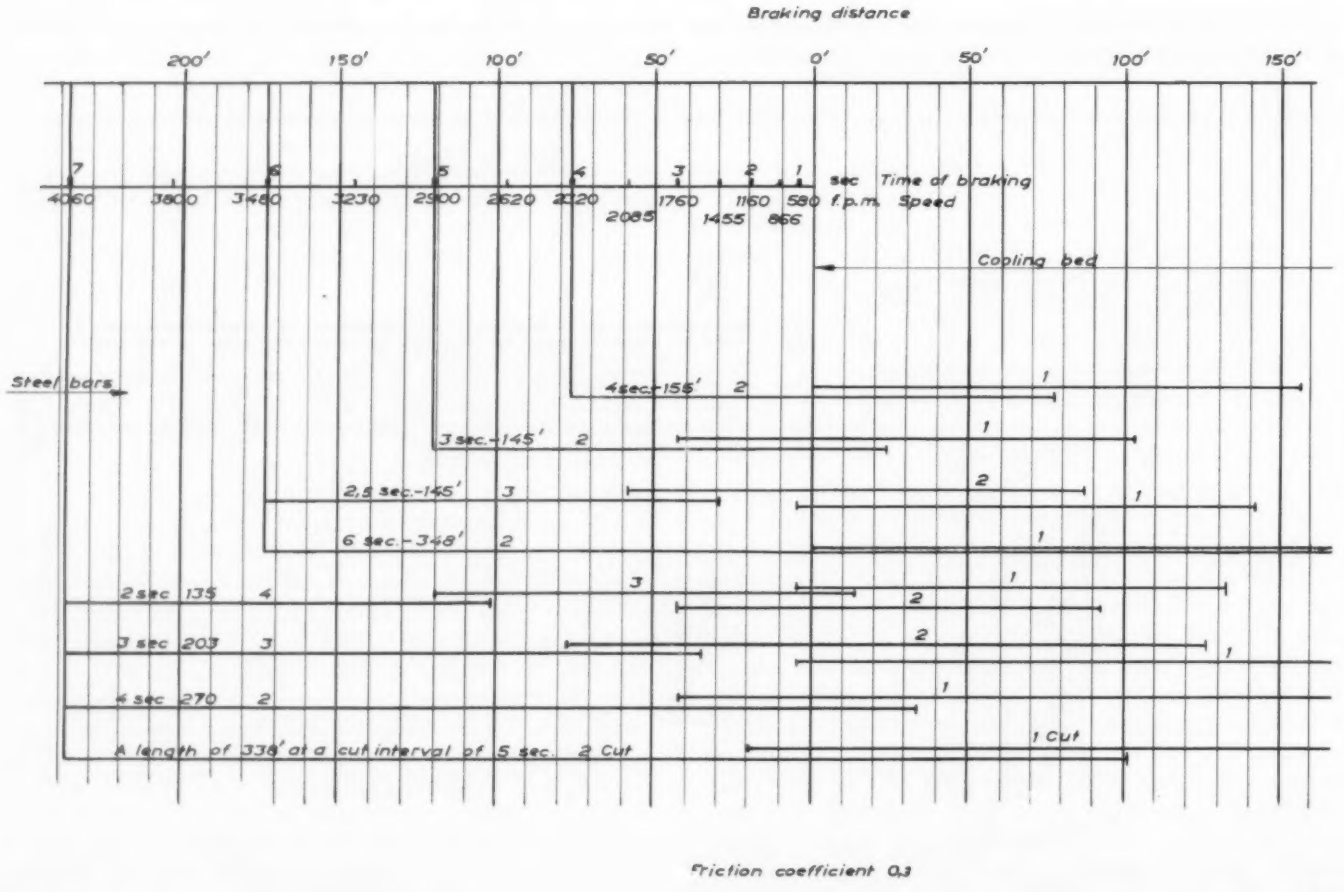
On the entry side between the bottom and the middle roll, Figure 57, there are two sets of side guides, so that there are two lower rolling-paths, one on either side of the upper central path. The left-hand guides are fastened to the left vertical roll chock and the right-hand guides to the right vertical roll chock. The entry guides thus follow the vertical rolls when these are set to different widths. During the latest years, the wear of the rolls has diminished to such an extent due to better roll quality that the design is being altered to allow either rolling with the rolling-paths directly below one another or alternatively displaced laterally.

The exit guides in the bottom position, Figure 56, are secured in the chocks of their rolls. On roll setting the entry guides and exit guides follow the vertical and horizontal rolls, repectively.

HIGH SPEED ROLLING TO COOLING BED

During the last few years a new method has been

Figure 62 — Examples show cut bar positions when broken down to standstill above the cooling bed from different finishing speeds and cutting lengths for coefficient of friction $\mu = 0.3$.



developed for rolling small sections to the cooling bed at high speeds. Hitherto reinforced concrete bars have been rolled at a finishing speed of 2000 to 2200 fpm (10 to 11 meters per sec) in modern mills. Lately speeds of 2800 to 3000 fpm (14 to 15 meters per sec) have been reached with common cooling beds of improved design, but then there are always great risks that a cut-off bar will go astray and cause accidents. It is a complicated procedure to guide bars at high speed to cooling beds of conventional design, and this difficulty is associated with uneven surfaces of the run-out roller table and the lifting flaps or pushing-off devices. The front end of the bar will easily get into a wrong direction and the bar will deviate from its straight course. Above all this applies to the smallest sections which are less stiff and are inclined to bend at the front end. Moreover, at high speeds the braking time and stopping distance are considerably extended, so that the succeeding bar will catch up with the preceding one.

The new method is shown in Figure 60. Immediately after the finishing stand the bar is cut in cooling bed lengths and guided to four different tubes. The finishing speed must be adjusted to suit the distance between the finishing stand and the cooling bed, so that the cut-off bar will stop right over the cooling bed. With a friction coefficient of $\mu = 0.3$ and a finish rolling speed of 2950 fpm, the braking distance is 125 ft (38 m). In consideration of the bending of the guide pipes and the difference in level of the bar at the shear and over the cooling bed, the practical braking distance is 92 to 100 ft (28 to 30 meters). When a bar has entered a guide tube and finally stopped, the guide tube turns over and the bar falls down in the first notch of the cooling bed.

The rotary shear, Figure 61, is revolvable about its vertical axis, and all movements of the shear and discharging device are pneumatically driven. The size range of application is normally up to ½-in. round. At present the finish rolling speed for ¼ to ½-in. bars is 3000 to 3200 fpm (15 to 16 meters per sec). The diagram, Figure 62, shows which stopping distance and braking time is required for varying finishing speeds. With a friction coefficient of 0.3 and a speed of 1700 fpm (8.7 meter per sec) a stopping distance of 43 ft (13 meters) is required, and the braking time is three sec. At 2900 fpm (14.7 meters per sec) the stopping distance is 120 ft (36.5 meters) and the braking time five sec. Thus the distance between the dividing shear or the finishing stand and the front end of the cooling bed has to be 120 ft. At 4050 fpm (20.4 meters per sec) the stopping distance is 232 ft (71 meters) and the braking time is seven sec. When cutting lengths of 134 ft (40.8 meters), the positions of the various bars are as shown in Figure 62. Three guide-tubes are consequently more or less filled. Since the dividing shear has been tested for finishing speeds of 3900 fpm (20 meters per sec) in another connection, it ought to be possible to use this device at such a speed.

As the bars are totally enclosed in the guide tubes until the final stop, they have no possibility of going astray and causing accidents.

TAKING OF SAMPLES

When rolling heavy sections of high-grade steel it is rather easy to take samples. In a wire-rod mill there

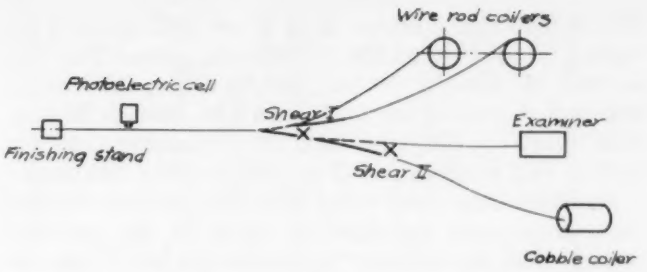


Figure 63 — Arrangement for automatic cutting of test samples at 4000 fpm.

are so many causes for surface defects that a continuous sampling and inspection is valuable in order to increase the quantity of approved coils. However, if rolling wire rod with great demands for a perfect surface, the results of the samples come much too late when conventional methods are used.

Figure 63 shows a diagram of a new arrangement for taking samples. The bad front end of the wire rod passes on its way to a cobble coiler. The two shears obtain an impulse from a photoelectric cell via time relays. The sample between the two shears is guided through a tube to the examiner's cabin and the test results from the front end of the bar may be reported after about one minute. After the first cut has been effected, the shears revolve automatically and when they obtain a cutting impulse from the tail end, a cut in the opposite direction is released. The second sample piece is guided through the tube to the examiner's cabin and by means of its kinetic energy the bad tail end is directed to the cobble coiler. This method of testing has been put quite recently into practice at a finishing speed of 4000 fpm (20 meters per sec).

COMBINED MEDIUM SECTION, SMALL SECTION AND WIRE-ROD MILLS

In the combined rolling mill, Figures 1, 2, 3, 4 and 5, the three or four first stands of the medium-section train are normally used for roughing down to the small-section and wire-rod trains, and stands 1, 4, 5 and 6 for medium sections. The small-section train compromises 4+2+2 stands or 4 x 2 stands, and the wire-rod mill has generally 4 x 2 stands.

The main motors are generally 265/750/1200 rpm at 235/660/660 kw or in some cases at 275/780/780 kw.

In high-grade steel mills it is necessary to use d-c motors, even in the medium section or roughing train, to be able to change the number of revolutions and by this means facilitate the bar biting. This is important when rolling heavy rounds and squares, and above all for complicated profiles. Ordinarily it is not necessary to use so powerful motors in the wire-rod trains, even if rolling the very hardest steel grades. The control of the big motors is, however, easier, and there is no difficulty in making full use of them when rolling heavy sizes, for instance ½-in. reinforced concrete bars at high speed in some of the wire-rod trains. Also the wire-rod motors are fully utilized, e.g., if rolling rounds up to $\frac{5}{16}$ in. (8 mm) at 4300 fpm (22 meters per sec) and $\frac{7}{16}$ in. (11 mm) at 3900 fpm (20 meters per sec).

The roll dimensions of the first stand are usually 18.5 to 21.6-in. diam x 71-in. barrel length (470 to

550 x 1800 mm), stands 2 to 6 are 18.5 to 21.6 in. diam x 59 in. (470 to 550 x 1500 mm), stand 7 is 12.2 to 16.5 in. diam x 40 in. (310 to 420 x 1020 mm), stands 8, 9 and 10 are 12.2 to 16.5 in. diam x 23.6 in. (310 to 420 x 600 mm) and the remaining ones are 9.45 to 14.2 in. diam x 15.2 in. (240 to 360 x 385 mm).

Finished bars from stand 6 in the medium-section train pass along the finishing stand of the medium-section train on their way to the cooling bed. From the finishing stand of the small-section train, stand 14, the bar may be guided either to the cooling bed or to the coilers.

In stands 1 to 4 and 7 to 9 the rolling speed is about the same and the loops grow in proportion to the coefficient of reduction, as shown in the rolling schedules, Figure 2. After stand 9, on the other hand, the number of revolutions and the roll diameters are regulated in such a way that there is little, if any, loop growth, from 0 to 9 ft.

The principle is thus to reduce as much as possible in the medium-section mill with loop growth, to secure rolling in the following small-section and wire-rod mills at the desired finishing speed without loop growth. In this way all the motors in the small-section and wire-rod mills always have about the same number of revolutions, independently of the size rolled. It is thus possible to diminish the field-weakening range, which contributes toward making the motors stable at varying load.

The temperature difference in the medium-section mill between the front and the tail ends is to a large extent eliminated in the small-section and wire-rod mills by the fact that the hotter front end radiates more heat and the cooler tail end absorbs more rolling heat. For example, a temperature difference of 125 F (70 C) between the front and the tail end on $\frac{5}{8}$-in. (16-mm) square was reduced to 40 F (25 C) on No. 5 gage (5.5-mm) wire rod in the finishing pass.

For 0.2-in. (5-mm) wire rod, Figure 2, all stands, except 5 and 6, are used. For $\frac{1}{4}$ in. diam (6.36 mm diam), shown in Figure 3 stands 4, 5 and 6 in the medium-section mill are free for rolling of other medium sizes. For heavier sizes the wire-rod trains are free, so that the three medium-section stands and all the stands of the small-section mill are used for $\frac{1}{2}$ in. diam (12.6 mm), shown in Figure 4, and for still heavier sizes stands 7 to 11 will be idle, Figure 5.

The rolling of 6 x $\frac{3}{8}$-in. flats is shown in Figure 2. It is convenient to roll such a medium section after having rolled a specified quantity of wire-rod or small sections so that several groove changes or roll changes have to be performed.

In rolling tool steel the depth of decarburization must be as small as possible. To meet this demand, the rolling mill should be designed so that a constant weight of stock passes through the mill per minute with a minimum of interruptions for size change, cobbles, etc.

The quality of the wire-rod is also to a great extent dependent on the continuous operation of the furnace. Since a standstill of only five or ten minutes is sufficient to deteriorate the surface of high-grade steel wire rod, it is most important that the furnace gets an even load per minute. This is difficult to accomplish in conventional furnaces, as the changing between medium sections, small sections or wire rod makes necessary the

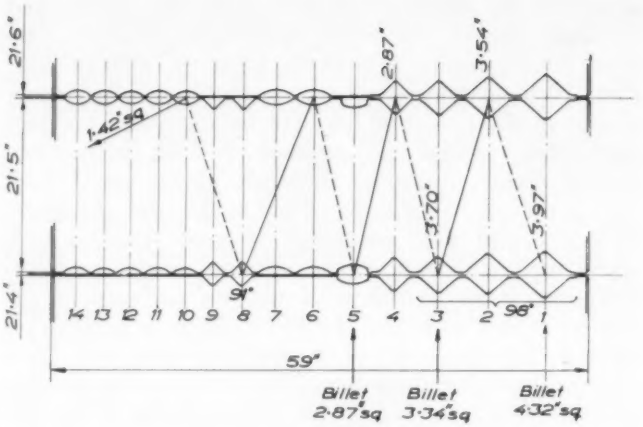


Figure 64 — Appearance of roughing-down rolls generally used for mills with large outputs.

use of various sizes and lengths of the billets, which easily might pile up in the furnace. However, the walking-beam furnaces, developed in Sweden during the last five years, have double walking beams and are well adapted for this purpose. For instance, one may use one line of billets, 18 ft long or two lines of billets, about 9 ft long. In the walking-beam furnace the billets may be fed back out of the heat zone in case of unexpected interruptions of the operation. When properly planned, rolling can go on without any important interruption, resulting from the alternation between medium sections and small sections or wire rod.

Figure 64 shows the typical appearance of roughing down rolls. Heavy billets, intended for rolling of medium sections, are reduced in diamond-shaped grooves to a suitable square, while it is convenient to make the billets for wire rod or small sections 2.85 in. square which in turn passes a thick oval and after that a thin oval that is guided to stand 2 by a repeater. When rolling wire-rod, billets weighing 310 to 640 lb (140 to 290 kg) are normally used. Billets weighing up to 880 lb (400 kg) are sometimes used for $\frac{5}{16}$ in. (8 mm) and heavier wire-rod.

When rolling 0.2-in. carbon steel wire rod at a speed of 4300 fpm (22 meters per sec) the finishing temperature is approximately 1750 to 1850 F (950 to 1000 C). For harder grades the finishing temperature is higher due to the larger deformation resistance. Owing to the large distance between the finishing stand of the wire-rod mill and the coilers it is possible to cool the wire rod so that a fine-grain structure and a negligible amount of scale is obtained.

For thicker wire rod up to $1\frac{1}{8}$ in. (28.5 mm) in coils finished in stand 14 it is more important that the distance to the coilers is short so that pinch rollers which could deteriorate the surface and the tolerances will not be needed.

Today the finishing speed of wire-rod trains is 4100 to 4300 fpm for high-grade steel and hitherto has been limited by the design of the coilers. Due to the centrifugal force the rod spirals create such a great pressure against the pins that they stick there and do not fall to the bottom. The bottom of the coil will then be empty and the end of the bar will overfill the coiler.

The repeater rolling can be started when the bar is sufficiently long to reach from one stand to the next. Thus, a billet weight of 440 lb (210 kg) is required for the oval before 1.8-in. (45 mm) square.

Leader and breakdown ovals are used to a remarkably great extent even with very hard steel grades of various sizes, also when rolling very small quantities. Previously it was generally considered that repeaters could not be used for hard steel grades with small lots of various sizes. Experience has shown, however, that rolling with repeaters of very hard grades is more reliable than rolling by hand. Hand rolling often causes cold front ends which leads to difficulties in the insertion and the catching of the bar. When rolling with repeaters great forces are pushing the bar in between the rolls so that there are no problems whatsoever with the catching. Moreover, the temperature is high and uniform which gives improved reliability in operation and consistent finished products. The design of repeaters and guides has been improved by degrees, and knowledge of correct adjustment of repeaters as well as guides has been gained by experience.

Nowadays the rolling schedules are so adapted that practically all grades, from the very softest to the hardest ones, may be rolled without appreciable adjustment of the rolls. It is thus possible to roll soft iron, telegraph wire rod, various grades of stainless and high-speed steels without other changes than a slight adjustment of the roll play and without troubles and interruptions of the operation. Accuracy, skill and experience are, however, necessary to successfully accomplish such advanced rolling.

On most of the rolled-steel qualities a smooth surface is demanded without rolled-in scale or seams and scratches. This is ensured by scalebreaking passes and roller guides for heavy bars, and in the case of small sections and wire rod by rolling with repeaters with very little loop growth. The roll diameter in the medium-section mill is usually 21.6 in. (550 mm), so as to permit the use of rather hard nodular rolls in the first stand and chilled rolls in the other stands, because it is important to keep a good groove surface for high-grade steel to avoid seams on the finished product.

To fulfill the requirements of close tolerances on high-grade steel it is not advisable to use continuous mills for wire rod either because of the stretching between the stands or the loop deflectors, where some stretching is also inevitable at high finishing speeds, as the rod has to be almost straight when the tail end passes. Otherwise a folded-back end or pig-tail occurs. In continuous rolling mills it is thus impossible to avoid completely some stretching. The front and the tail ends are not stretched as long as they run freely between stands and, therefore, the dimensions for the rod will vary. When rolling with repeaters the stretching can be fully eliminated, which gives closer tolerances.

Many of the grades rolled have a very limited temperature range within which rolling is possible (e.g., high-speed steels). These grades thus have to be rolled at a practically constant temperature from the roughing down to the final pass. Thin bars require a final rolling speed of 3000 to 4000 fpm (15 to 20 meters per sec).

When rolling with repeaters about all the same advantages are gained as in continuous mills in regard to constant and high finishing temperature and short time between passes to reduce scaling. Generally, a high rolling temperature is desired, because the surface is then less liable to form folds, which grow worse

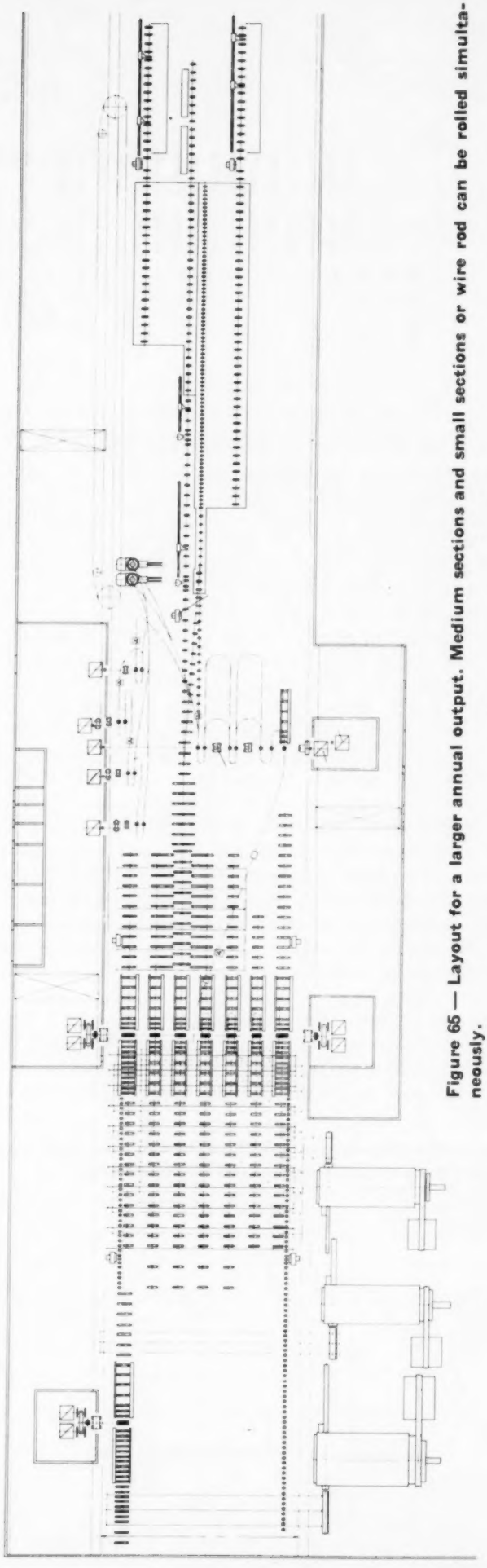
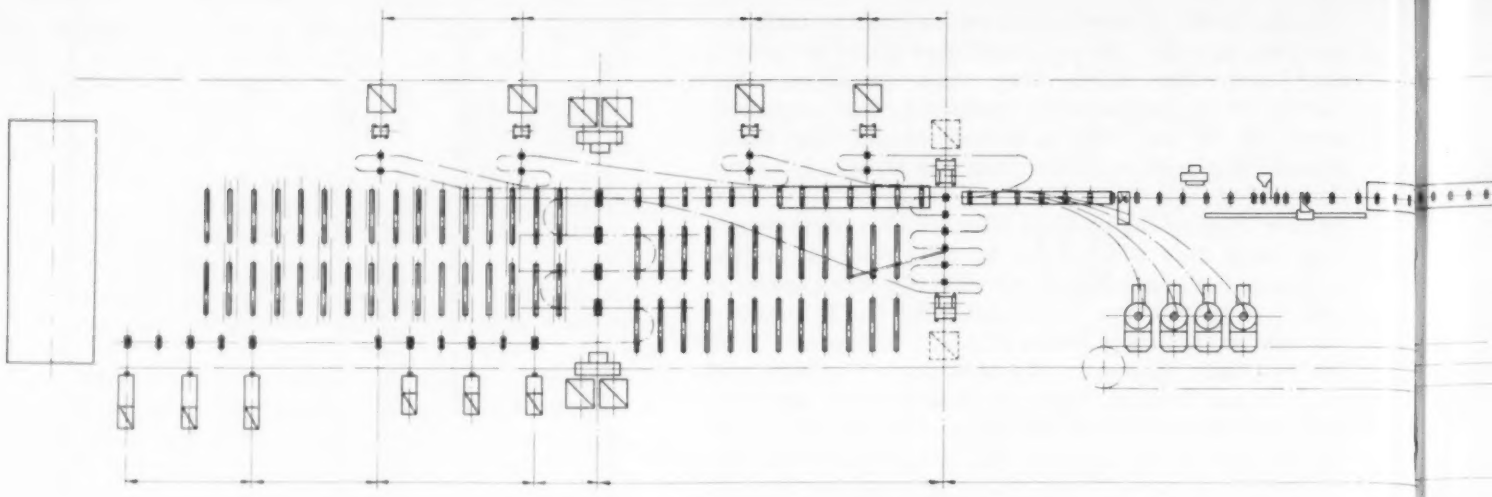


Figure 65 — Layout for a larger annual output. Medium sections and small sections or wire rod can be rolled simultaneously.



during the rolling and form fissures and seams.

In steelworks for high-grade steels there are often small quantities of high-alloy tool steel which require different furnace temperatures and billet weights than for the main products. If this is the case, it may be convenient to use a portable furnace to heat such billets. To satisfy such a requirement, the first stand in the intermediate mill is made three-high with a normal roll diameter of about 13.5 in. (340 mm). A portable furnace can be placed near this stand where the roughing may be done, and afterwards the bar is rolled down by hand or in repeaters through the intermediate mill and the wire-rod mill. All the repeaters and their supports may be taken away to allow hand-rolling of profiles. The portable furnace may also be moved to the first or the fifth stand in the medium-section train for rolling small quantities in the last free stands. All the medium-section stands are equipped with motor-driven screwdown for both the top and the bottom rolls, and the rolls may be adjusted between the passes. This is necessary when rolling small high-speed steel ingots, which in addition to very small drafts also require many reheatings before the ingot structure is broken down.

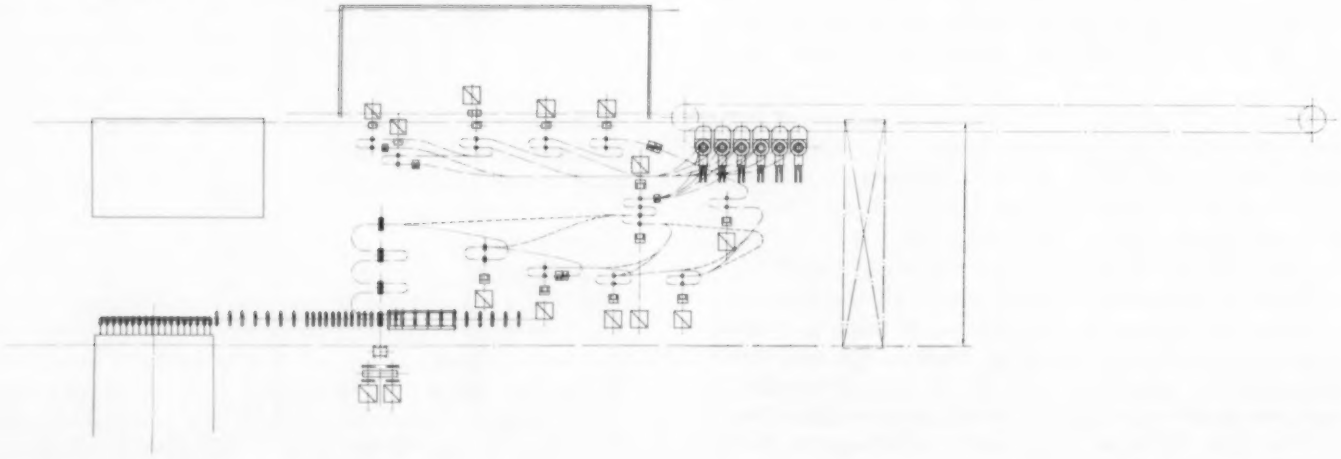
In the runout roller table to the cooling bed there are hot shears and a hot saw, mainly intended for medium sections. The cooling bed is designed for bars from 0.2 to 6 in. (5 to 150 mm) diam and flats up to 12 in. (300 mm) wide. As it is important to get high-grade steel bars as straight as possible directly from the cooling bed, this is provided with notched walking beams.

Figure 65 shows a layout which has been used for some projects involving large annual outputs. Wire-rod and medium-sections may be rolled simultaneously, and the mill is equipped with two furnaces and two cooling beds. The roughing mill, for the medium-section train, has not yet been installed but can be added in the future. Figure 66 shows another layout, intended for rolling of various thin profiles, bars up to 2.4 in. (60 mm) and high-grade wire-rod down to 0.2 in. (5 mm). The four 12-in. diam stands may be adjusted while thin profiles are rolled in the 10-in. diam small-section train. In this case the billets come directly from the continuous roughing mill.

Hitherto hand-rolling in diamond-shaped grooves has been used for producing every square needed for medium-sections and profiles in a three-high rougher. Therefore it might be of current interest to replace the roughing three-high stand with a continuous roughing mill even in combined mills for high-grade steel. However, every second stand of the continuous roughing mill must be made with vertical rolls, and each stand has to be driven separately.

Figure 67 shows a layout of a wire-rod mill intended for large production of high-grade steel wire rod, the

Figure 67 — This wire-rod mill is intended for a large output of high-grade steels, the heavy sizes being rolled in small lots when changing grooves or rolls for 0.2 to ¼-in. rod.



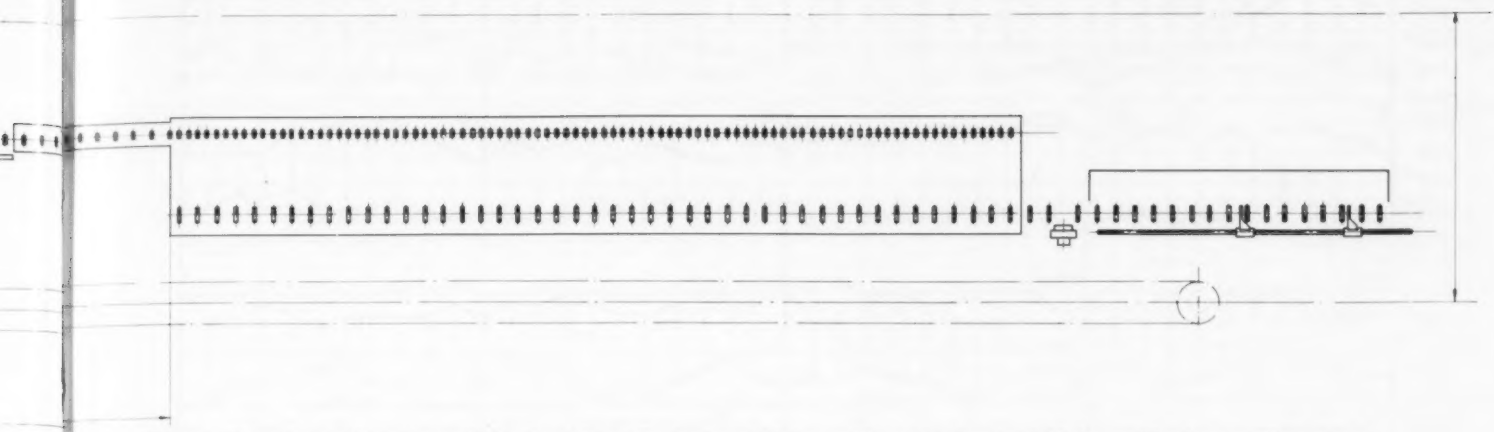


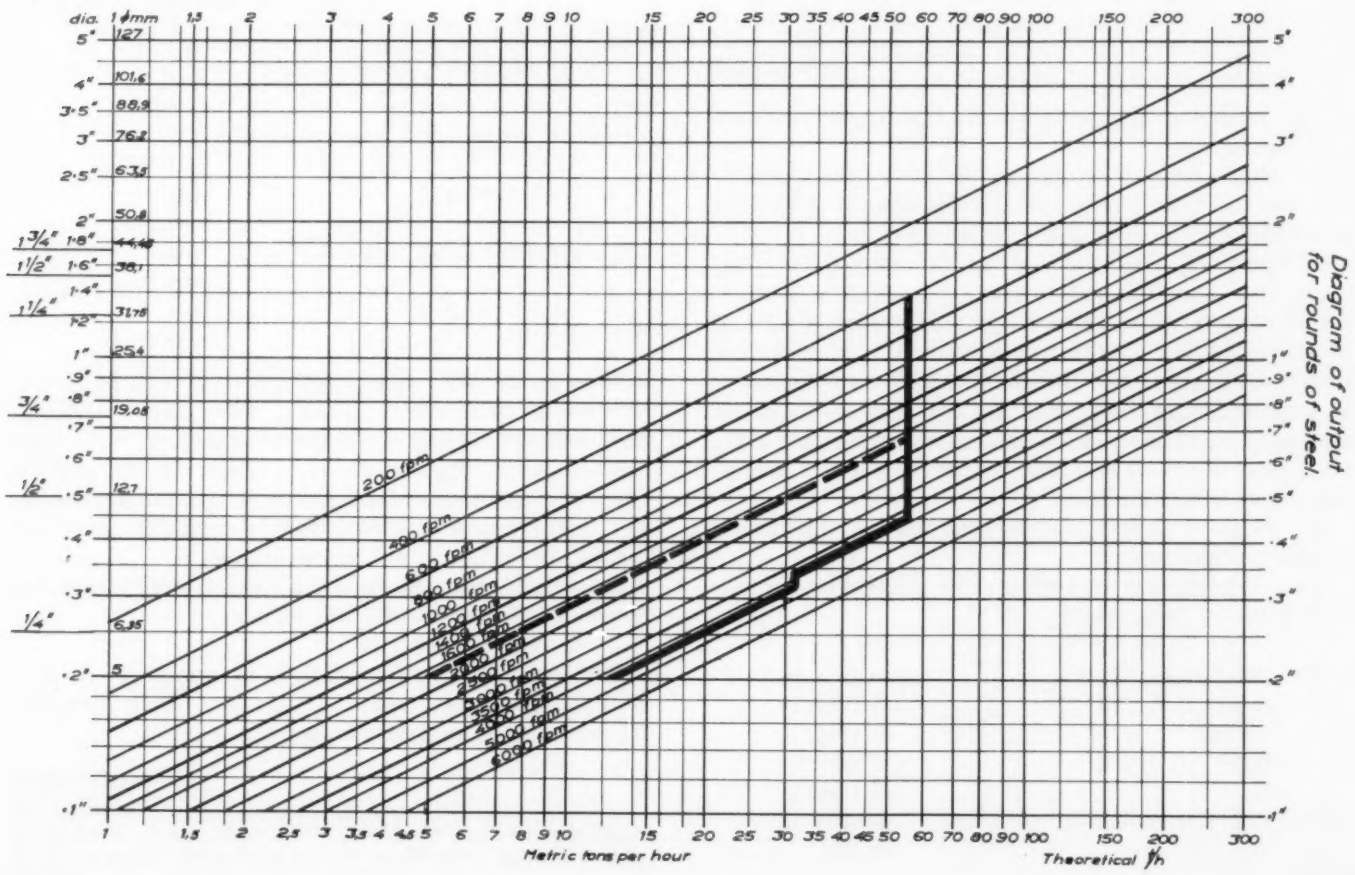
Figure 66 — A continuous mill feeds either the 4-stand 12-in. mill or the 6-stand 10-in. mill when rolling profiles of intermediate or small sizes respectively. Both the 12 and 10-in. mills are used when rolling 0.2 in. wire rod.

heavy sizes being rolled in small lots. The intention is to roll a certain number of tons of 0.2 and 0.22-in. (5 and 5.5 mm) wire rod, and when changing grooves or rolls, to roll small quantities of heavy wire rod.

The output of the combined rolling mills is limited either by the furnace capacity, the production in the roughing stand or the production in the finishing stand. The production is reduced by frequent changes of sizes, and by changing of rolls and grooves. Since long billets may be used even for high-grade steel, the production in the roughing mill is no longer a problem. The theoretical output in the finishing stand is shown in Figure 68.

By theoretical output is understood that a bar passes through the finishing stand all the time, without intermissions between the various billets. At a speed of 4300 fpm (22 meters per sec) for 0.2-in. (5 mm) wire rod, a theoretical output of 14.0 net tons per hr is obtained. Often even larger output is required and for this reason short test rollings have been made with two strands. During these tests no difficulties occurred and the tolerances deteriorated by about 0.0008-in. (0.02 mm). The dotted curve marks the production at a finishing speed of 1700 fpm (8.5 meters per sec). This is normally the highest finishing speed for high-grade steel to the cooling bed.

Figure 68 — Theoretical output is given as a function of the finishing size and speed. Dotted curve for bars to the cooling bed. Continuous line for wire rod.



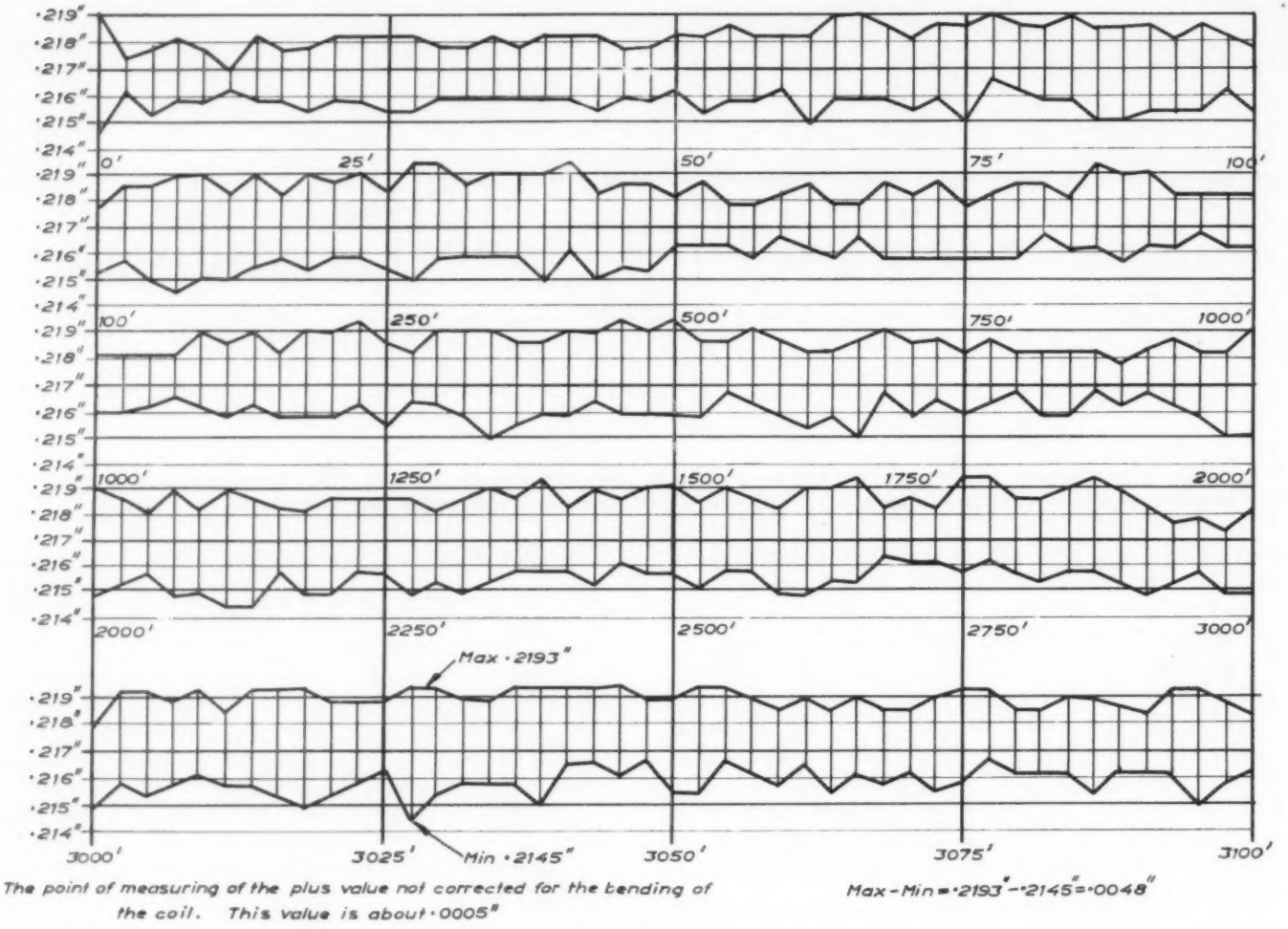


Figure 69 — Size variation on 0.217-in. wire rod from 375-lb billet. Maximum is 0.2193 in., minimum is 0.2145 in. = 0.0048 in. difference. Allowed tolerance is ± 0.004 in.

SUMMARY

The following advantages with high-speed repeater mills are mainly:

1. Half as many motors are required which means simpler electrical equipment and less chance of trouble caused by fluctuations in the electrical system.

2. Between the wire-rod trains, automatic loop regulation repeater are used with adjustable loop length two or three times longer. Furthermore, if the speed is too low in the following wire-rod train, the loop can run into the whip-channel and then gradually be caught during the pass-time. It is thus much easier and safer to set for a new size than in continuous mills with loop lifters. There are no movable parts except the rollers in the guides.

3. There is no risk of stretching the rod: this results in better tolerances.

Two looping and repeating mills guarantee the following closest tolerances:

Rod diam, in.	Tolerance, in.
0 22 to 0.275	+0.004
	−0.004
0.28 to 0.395	+0.00475
	−0.00475
0.4 to 0.59	+0.006
	−0.006
0 275 to 0.4	+0
	−0.006
0.4 to 0.7	+0
	−0.007
0.7 to 0.8	+0
	−0.008
0.8 to 1.2	+0
	−0.013
1.2 to 2.0	+0
	−0.015

As the guaranteed tolerances are to a certain extend dependent on personal opinion, skilled labor, the tonnage rolled in the grooves before changing, etc., some size diagrams, Figures 69, 70, 71, and 31, 32, and 33, from wire-rod coils or bars, taken at random are shown.

4. The amount of cobbles is probably less, but comparative figures are not available.

5. Samples can be cut from the tail end in each pass to check the section and the surface.

6. Lower capital costs.

The combined rolling mill is in operation in nine Scandinavian steel works. There are three complete mills in France and one in Japan.

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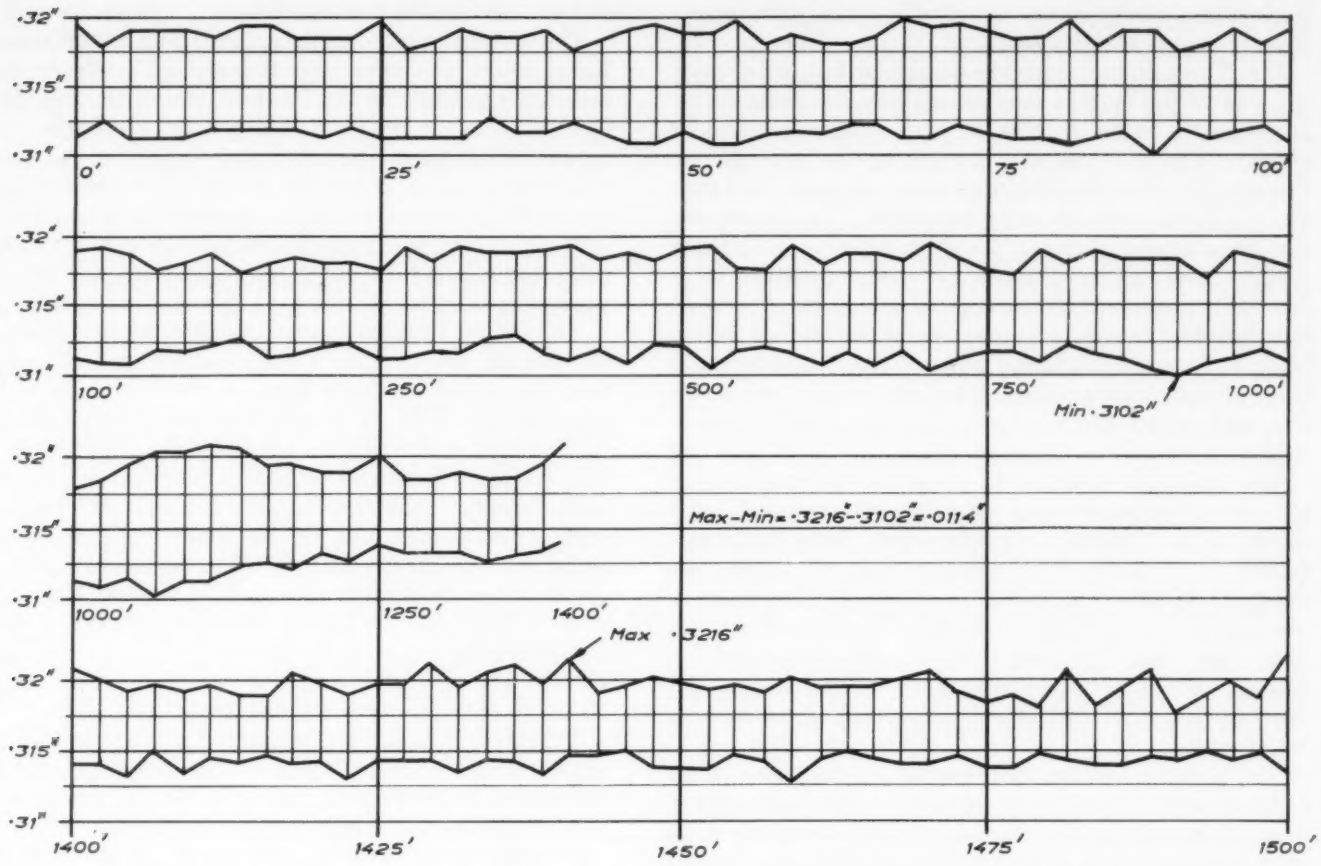

The point of measuring of the plus value not corrected for the bending of the coil. This value is about ·0005"

Figure 70 — Size variation on 0.315-in. wire rod from 400-lb billet. Maximum is 0.3216 in., minimum is 0.3102 in. = 0.0114 in. difference. The roll setting could, if necessary, be made better.

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Discussion

PRESENTED BY

E. C. PETERSON, Vice President, Rolling Mill Equipment Div., Birdsboro Corp., Birdsboro, Pa.

L. J. SPIVAK, Superintendent, Roll Shop, Republic Steel Corp., Gadsden, Ala.

H. H. CAMPBELL, Division Superintendent, Bar Mills, Midland Works, Crucible Steel Co. of America, Midland, Pa.

ERIK NORLINDH, Morgardshammars Mek Verkstads AB, Morgardshammar, Sweden

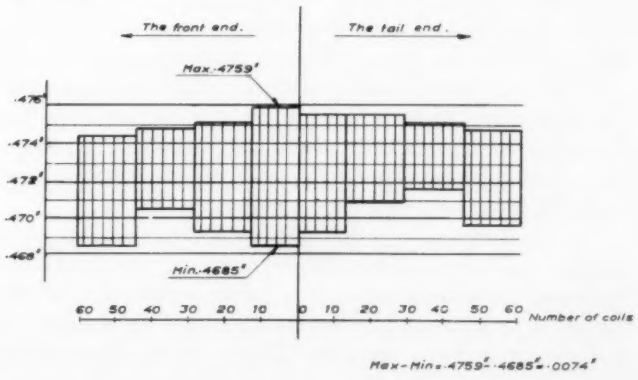
E. C. Peterson: Mr. Norlindh's paper should elicit a lot of interest in this country. It is not only an excellent presentation of the way the Swedish industry has been building mills and rolling on them, but it also describes some equipment that is very novel to this country.

I would like to discuss some of the differences between their equipment and the rolling practice for rolling alloy specialty steels as contrasted with the way it is being done in the modern mills in this country.

My first impression, on looking at the layouts of the Swedish combination mills, is that they are spread around so much that it would be difficult to roll a coil of commercial weight as demanded by the trade in this country, at any reasonable rolling temperature. However, in going through the paper further, I concluded that they do accomplish it with high-speed repeating. We try to accomplish the same thing with a more compact layout and three- or five-stand continuous finishing mills.

In going to high speeds, Mr. Norlindh's organization has had to develop some very highly refined equipment and repeating practice because repeating setups that will

Figure 71 — Size variations on the front and tail ends on 61 wire-rod coils. The roll setting could, if necessary, be made better.



work satisfactorily of low speed will often cause excessive cobbles at higher speeds.

Mr. Norlindh mentioned in his paper that he believes the cost of the type of equipment they are using to be less than the types of mills we have in this country. It appears to us that material of construction is cheaper in this country than in European countries, and that machining labor is much more expensive. For this reason American manufacturers tend to build heavy and simple designs, as compared with European practice. Mr. Norlindh mentioned that weight of one of his stands as only half that of a conventional stand the way we would build it. I question whether some of their equipment, if built in this country, even at half the weight, would be less, and might well be more, expensive than our conventional stands.

Mr. Norlindh describes in his paper the practice for setting up guides and the repeaters on their mills. He mentions that a keen eyed man is a good thing to have in setting these guides. We know here that sometimes, because of our union regulations, it is not possible to get a keen eyed man on the job you want. There are also many gages that Mr. Norlindh mentions that are used for setting up. Our crews seem to have trouble finding the right liner. I hesitate to think what might become of a set of gages.

The author mentions that they have a practice in their mills of allowing for the spring of the rolls under load. In setting up the roll the roller is apparently supposed to make this allowance, but they have some difficulty in getting the roller to make that allowance.

I am afraid that maybe we have too many individualists to be able to introduce many of these refined precision practices. I am reminded of a conversation I had with a superintendent of an alloy rod mill in this country about his roller guide practice. He told me that the roller guide functions very well as long as they change and lubricate them regularly. I asked him how often they change and he said, "we take them out at the end of every turn." He continued, "we might as well, because every time a new turn comes on, the roller has to set up everything to suit himself anyway for it will not work the way the other roller had it."

Another item Mr. Norlindh mentioned is that the medium section part of their combination mill is arranged so the repeater can be taken out, leaving the floor clear for manual stranding or looping. That does not work very well in our mills because when you put a man on you have him from then on, whether you work him or not. So here it is desirable to mechanize operations completely, or not at all.

Mr. Norlindh states that it is not desirable to apply repeaters unless universal spindles are also used. We agree, and we sell universal spindles for use with repeaters. We find, however, that domestic mills do not want to pay the initial cost of that equipment even when they are going to do repeating, or to have the bother of handling them after they are in the mill. We find, therefore, that in this respect, it has been necessary to live with the loose coupling butts we have.

The modern mills in this country have been going to a mechanical escapement type of repeater, where the bar is closely contained when it is being repeated, and this makes it possible to handle bars that may have knuckles in them from loose spindles. They are also less critical as far as setting the twist guides.

The author spoke briefly on oval and round reductions, which are very well thought of lately in this country, especially in the finishing end of the mill. It is believed they do improve quality. Mr. Norlindh mentioned in his paper the difficulty of guiding the small ovals into round reduction passes. We have recommended and seen used, with success, an oval to oval series of reductions in the finishing stands which minimizes the guiding difficulty and appears to give the advantage qualitywise of the oval to round reductions.

The author states that up to the present time most of the squares required for their combination mill reductions have been made by hand, on three-high mills. He suggests that it might be interesting to consider the use of a continuous vertical and horizontal roughing mill to take the place of such a breakdown mill. We have applied with success, in this country, the use of a two-high reversing screwdown mill for this task, which we would certainly recommend as a solution because it gives so much more flexibility. We believe further that continuous mills that are tied in directly to the speed of the finishing mills roll so slowly that the bar is cooled appreciably. The reversing mill can get the bar run down faster than the continuous mill, therefore hotter.

I believe, in looking through the tolerances that are shown in Mr. Norlindh's paper, that they compare very closely with the type of work that can be, and is being done in the specialty steel mills in this country.

I would like to ask Mr. Norlindh one question. He spoke about some $\frac{3}{4}$-in. bars that were rolled in repeaters from billets which could not be rolled at all in the continuous mill. I would like to ask him what it was about those billets that made them unrollable in the continuous mill, and why it was possible to roll them in the repeating mill.

In conclusion I would like to say that it appears to me that the results that are being obtained in Swedish type mills, as compared with ours, are fairly similar, but that they are being obtained by a radically different approach which is probably dictated by differences in the economic climate and the labor market between the United States and Sweden.

L. J. Spivak: Mr. Norlindh mentioned that in changing small sections on the finishing train, they roll a medium section on the intermediate train to cut down over-all mill delay. In order to get an idea of how often rolls are changed, please tell us the average tons per size rolled on the finishing train. Also, what is the average tons per hour for $\frac{1}{2}$-in. round?

H. H. Campbell: Would the author answer the following questions?

1. What material is used in your repeaters?
2. What material is used in your stripper guides?
3. Are you troubled with shearing and/or scratching from your stripper guides due to the close settings? I see that you have made no allowance for twist in your stripper guides and I am wondering if the twist caused by the repeater does not give you serious trouble at the guides.
4. There is also a serious doubt in my mind as to the constancy of twist from grade to grade of steel rolled.

These are questions which I feel would normally be asked by an operating man and which you may feel have some merit.

Erik Norlindh: I very much appreciate Mr. Peterson's comments and acknowledge that he has, with great cleverness, searched out the points where the opinions differ.

In Sweden, alternating two-high and three-high trains have almost exclusively been used in high-grade steel mills.

The new type of mill stands has been developed in order to create the best conditions for a reliable repeater rolling without twist-guides. Repeater rolling with twist-guides has not proved reliable when rolling the varying steel qualities and the small quantities frequently occurring in Swedish high-grade steel mills.

The new mill stands have been designed to be at least as resistant against roll pressure and other forces as are conventional mills. At the same time the direct transmission of the roll pressure from the bottom roll chocks to the top roll chocks has reduced the mill spring to about one third and the weight to about one half.

During the 13 years that the new stands have been in operation, two roll chocks have been destroyed, because the mill could not be stopped until 15 minutes after the roll break, and three mill screws have been broken, which should be judged in the light of the fact that currently more than 400 mill stands are in operation.

The supporting posts are made sufficiently strong to resist the accelerating forces from the heaviest bar, and also the tensile force if a bar is pulled off in a repeater in the case where the tail end gets caught in the exit guides.

Some rolling mill technicians prefer heavy mass in the stands, but our experiences have consistently shown great advantages with easily accessible guides, Figure 53 and easily handled roll units, which would not be possible with bulky and heavy roll units.

Further, our experience has shown that not only the material of construction but also the machining labor is cheaper than that with conventional stands of modern design. The essential thing is, however, that such stands have become more apt for their purpose.

The setting of a combined rolling mill naturally requires a certain accuracy, but it is not more difficult than the setting of other rolling mills. We have spent very much time and work on making the setting so simple, reliable and exact that the rolling can be started without the risk of cobbles and with close tolerances, also with varying steel qualities and small lots. Over the last five years, trial bars have only seldom been used in our mills; the rolling starts at once with first quality billets. The gages are used in the roll changing shop and the only linear generally used in the mill is a pocket spirit level.

The small mill spring of the new mill stands is a great advantage when setting for different sizes and qualities. When rolling ½ in. round, the roller has to adjust the roll clearance 0.002 in. between carbon steel and high-speed steel to obtain the same finished size, while, for carbon steel and low alloy steel, he need not make any allowance at all for the spring.

Mr. Peterson's indication that each turn readjusts all the guides accords with our experience from the old rolling mills. In the repeater mills it has been easy to convince the rollers of the correct and most reliable setting, which is practically identical for all existing steel qualities. This should of course be out of question if twist-guides were used in the oval repeaters. Readjustment of the guides between the turns does not exist in any of our installations.

The medium section part of the combined rolling mill is normally used for hand rolling, with the aid of roller tables and tilting tables. The total number of people required in the rolling mill is then generally the same as when rolling bars and wire rod. However, in some mills, large quantities in the size range 1⅛ to 1½ in. or in some cases up to 2 in. are rolled by means of repeaters in the medium-section train. In such rolling, fewer men are required. Assembly and dismantling of repeaters and guides are made by the people in the roll changing shop, while the crew is rolling small sections of wire rod.

Rolling with repeaters in mills with wobbler couplings is still practiced in a few rolling mills in Scandinavia, but experience has shown that it pays to replace the old mill stands by new ones equipped with roller bearings and universal couplings, because the reliability is much higher. This replacement has been made to a very great extent. Certainly the universal couplings are expensive but not so much after standardization to a small number of sizes, with accompanying rationalization of manufacture. The most important thing, however, is that it has been possible to reduce the maintenance costs by manufacturing the couplings as per the grease bath principle. Probably, the amortizing and maintenance costs are lower than those for wobbler couplings. We have not been able to obtain a fair comparison,but this is a matter of small importance considering the increased reliability of the rolling mill.

In the beginning, twist guides were used in oval repeaters but they did not give a satisfactory reliability when rolling the varying steel qualities and small lots with which we had to deal.

Not until the oval repeaters and the inclination of the repeaters were designed in such a way that the twist guides became unnecessary, could rolling with repeaters be introduced in the high-grade steel mills.

To get a comparison between the oval-round and oval-square series on high requirements of the steel surface, we have tried unsuccessfully to encourage some rolling mills to test the oval-round series for ¼-in. rounds. They consider that there is nothing to gain but rather a risk of loss. A certain point on the surface can be exposed to free spread in two consecutive passes, because the round section can run in the following oval without turning itself.

On the limited tests that have been made, it has not been possible to observe any improvements. The disadvantage of the oval-round series is that additional passes are required and that the oval must be held by the guide in the round groove, while standing by itself in a square groove. The oval-oval series has not been tested in Sweden.

Since walking-beam furnaces for high-grade steel were introduced decarburization can be avoided and the heating of various qualities be made even with relatively thin and long billets. In the last few years the billet size has thus been reduced to 2.87-in. square for 0.2 to 1¼-in. finished round, and the roughing down is made automatically as per Figure 64. Consequently

it is at present only necessary to hand-roll heavier billets down to 2.87-in. square for heavier medium sections than 1¼-in. rounds. It is a good idea to make this roughing down in a two-high reversible stand instead of a continuous roughing mill.

The example of repeater rolling to ¾ and 1-in. reinforcement bars from top billets which previously were scrapped owing to such severe pipe that they gave too many cobbles in a continuous mill with twist-guides, was intended to show that the combined mill is not too sensitive to pipe and flakes. On repeater rolling without twist guides the guides are designed in such a way that even rather large overfills and flakes may pass without cobbling. It is possible that the guides in the continuous mill could have been designed in a better way with regard to overfill.

In answer to Mr. Campbell's questions, the repeaters and delivery guides are always made of grey cast iron. As the function of the stripper guides is neither to twist the bar, nor to straighten a knuckled front end, but to guide the bar to the repeater and prevent wavy formation between the delivery guides in case of a violent throw-out of the repeater, the stripper guides are set rather open, if compared with the tight setting in continuous mills with stripper twist-guides. As to the twist caused by the oval repeater, the gap being relatively large, there is no reason for making the stripper guide groove twisted. It is true that we did so formerly, but it has been relinquished many years ago, due to the fact that it was easier to manufacture and check the stripper guides without the twisted groove. Anyhow, the stripper guide groove must be so open that the oval will not be twisted by force. The repeating of various qualities and oval sizes will not be reliable if the stripper guides take part in the twisting. The stripper guide groove is further made so wide that overfills may, as far as possible, pass through.

The stripper guide opening is adjusted in the roll changing shop and cannot be changed in the mill, and, therefore we have never had any troubles with shearing and scratching in the stripper guides.

In answer to Mr. Spivak, it is really difficult to give the average tons per size rolled on the finishing train because it varies within a very large range between one or two tons up to 100 tons or more between the different steel plants. The average tons per hour for ½-in. rounds is two tons in some mills and in other mills 20 tons. ▲

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system analysis and design

for hot strip mill with automatic gage control

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Analog computer studies were made prior to designing thickness regulators. . . . . in actual practice, regulators performed in accordance with the predictions made by the computer studies. . . . production results have been excellent.

SINCE six or seven stands are available for control of strip thickness, a number of regulating systems are possible. However, it is the purpose of this paper to discuss the computer study and resulting design of the gage control for the hot strip mill at Columbia-Geneva's Provo plant. The mathematical analysis outlined is, however, common to all hot strip finishing mill·.

MATHEMATICAL ANALYSIS

From a mathematical standpoint the analysis of a hot strip finishing mill is basically the same as that of a tandem cold strip mill. Since a complete report on much of this approach is given in a readily available publication (1),* it seems only good judgment to omit that which would be repetitious.

There are two differences between the two types of mills which are important: both arise because the hot strip mill works metal at elevated temperatures. When metal is rolled cold there is slipping between the roll and the strip except for a point or very small region called the neutral point. The steady-state calculation of roll force and torque was handled in the above reference in the manner suggested by Bland and Ford (2) which assumes a constant coefficient of friction in the roll bite with the friction force changing direction at the neutral point.

When metal is hot, however, it tends to stick to the rolls throughout the whole roll gap. A boundary condition different from that used by Bland and Ford is required. In the case of hot rolling the tangential friction force is equal to the yield stress of the metal in shear. Sims (3) has solved the steady-state roll force and torque calculation problem and his method was employed to obtain the numerical values used here. Even though the surface speed of the metal being rolled is equal to the work roll peripheral speed throughout the roll gap, there is a plane in the roll gap where the speed of the strip is uniform and equal to the roll peripheral speed. This is the neutral plane and is exactly analogous to the neutral point in cold rolling.

The other difference in hot rolling is that the strip is plastic when it passes between stands rather than elastic as in cold rolling. Due to interstand tension it tends to stretch without recovery, thereby losing cross section. This process of deformation requires a finite time and is, therefore, called "creep." As has already been implied, it is more pronounced as temperature increases. Also, the rate increases with tension. If the tension is small, the "creep" can be regarded as negligible. The authors feel that an automatic gage control system for a hot strip mill must maintain low tensions to avoid width variations in the final product. Therefore, the strip has been considered to be elastic between stands, i.e., no appreciable "creep." This permits the derivation of equations which are exactly the same as those in the cold mill paper (1).

As in the example of the tandem cold mill (1), equations of this form may be written. Nomenclature is as follows:

Summary of nomenclature

A = strip cross-section area, sq. in.
Δ = change from initial value
F = total roll separating force, millions of lb
h = strip thickness, in.
L = length of strip, ft
M = combined spring constant, millions of lb per in.

* Numbers refer to Bibliography at end of paper.

p = operator = d/dt
S_o = screw position, positive upward, in.
T = total tension, lb
v = velocity, fps
τ_m = motor load torque, lb-ft
τ_r = rolling torque, lb-ft

Subscripts

1, 2, 3, 4, 5 = when used alone indicate nominal values between stands 1-2, 2-3, 3-4, 4-5, 5-6, respectively
i = indicates incoming side
o = indicates outgoing side
n = neutral plane

$$\frac{\Delta F}{F} = K_1 \frac{\Delta h_o}{h_o} + K_2 \frac{\Delta T_i}{A_i} + K_3 \frac{\Delta T_o}{A_o} + K_4 \frac{\Delta h_i}{h_i} \quad (1)$$

$$\frac{\Delta \tau_r}{\tau_r} = K_5 \frac{\Delta h_o}{h_o} + K_6 \frac{\Delta T_i}{A_i} + K_7 \frac{\Delta T_o}{A_o} + K_8 \frac{\Delta h_i}{h_i} \quad (2)$$

$$\frac{\Delta h_n}{h_n} = K_9 \frac{\Delta h_o}{h_o} + K_{10} \frac{\Delta T_i}{A_i} + K_{11} \frac{\Delta T_o}{A_o} + K_{12} \frac{\Delta h_i}{h_i} \quad (3)$$

It has been shown that roll force, outgoing thickness and screw position are related in the following manner.

$$\Delta F = M [\Delta h_o - \Delta S_o] \quad (4)$$

Table I shows a typical schedule for reducing mild steel 28 3/4 in. wide from 800 mils to 87 mils delivering at 2300 fpm. The spring constant for a mill stand is taken as 10,000,000 lb per in. Included is a tabulation of the K's for equations 1, 2 and 3.

Since the mathematical operations required to produce a complete set of equations for a six-stand finishing mill are exactly the same as for the tandem cold mill, they will not be repeated here. It is much more in line with the object of this paper to handle the example at hand in an expeditious manner. The analytical approach was utilized to study the installation described by Ringger and Koss (4) in the early stage of its development.

ANALOG COMPUTER STUDY

Tests had been made at the Geneva Works which showed promise of some measure of effectiveness of gage control by tension at the delivery end of the mill. During the analytical study approach we worked with U. S. Steel engineers in verifying data and analyzing results. To avoid setting up the six-stand mill in complete detail on an analog computer, certain simplifying assumptions were made. The speeds of stands 1 through 4 were assumed to be held constant by the stand speed regulators. It was assumed that, although speed changes in stands 5 and 6 would have a slight effect on tensions earlier in the mill, the effect on strip thickness in the first three stands could be neglected.

Figure 1 shows a block diagram of stands 4, 5 and 6 as they were represented. The numerical values shown were calculated for the schedule of Table I. The object of the computer study was to establish the effectiveness of gage control utilizing speed changes in stands 5 and 6. Since it was assumed that the speed regulator on stand 4 will hold the speed substantially constant, it is not necessary to show the stand 4 motor in this diagram.

At the extreme left of the diagram there is a block which is labeled "Hardness Variation Function Generator." This should be explained in some detail. It is assumed that the cold spots resulting from the water cooled ways in the reheat furnace manifest themselves as hardness variations of triangular shape. As the cold spot passes through a stand the rolls spring apart. If the roll opening were held constant by moving the screws there would be an increase in rolling force. This has been assumed to be a 15 per cent change in force in each stand, that is, a 15 per cent hardness change. The base was assumed to be five seconds wide. Since the cold spot has already passed through stands 1, 2 and 3 and those stands have sprung successively, there will be a thickness variation accompanying the hardness variation as it enters stand 4.

The combination of these two disturbances manifests itself in two ways. Through the constant 0.38 it affects the thickness delivered from stand 4. Through a second constant 0.014 it affects the tension between stands 4 and 5.

It will be noticed that the generated function also passes through a block marked $\bar{e}$ (pL4/4*O*). The quantity L4 is the distance between stands 4 and 5 and 4*O* is the strip velocity between stands 4 and 5. Thus

TABLE I
Typical Finishing Mill Rolling Schedule

	Stand					
	1	2	3	4	5	6
h_i, in.	0.8000	0.4720	0.2830	0.1840	0.1290	0.0970
h_o, in.	0.4720	0.2830	0.1840	0.1290	0.0970	0.0870
T_i/A_i, million psi	0	0.0040	0.0040	0.0040	0.0040	0.0040
T_o/A_o, million psi	0.0040	0.0040	0.0040	0.0040	0.0040	0
F, million lb	0.7572	1.4696	1.5778	1.4874	1.3179	0.6469
h_n, in.	0.5354	0.3129	0.2013	0.1394	0.1034	0.0891
τ_r, lb-ft	134,000	180,000	138,500	95,800	63,300	16,600
K_1	−1.461	−1.562	−1.911	−2.370	−2.974	−7.041
K_2, per million psi	...	−19.940	−13.513	−11.169	−10.232	−12.645
K_3, per million psi	−36.248	−13.182	−9.840	−8.671	−8.341	...
K_4	1.629	1.678	1.993	2.403	2.957	6.934
K_5	−1.993	−2.171	−2.698	−3.400	−4.340	−11.29
K_6, per million psi	...	−28.972	−19.306	−15.472	−13.652	−16.182
K_7, per million psi	−15.929	−5.621	−4.340	−3.918	−3.833	...
K_8	2.705	2.817	3.336	4.018	4.964	12.281
K_9	0.834	0.827	0.811	0.799	0.788	0.775
K_{10}, per million psi	...	−2.429	−1.483	−1.001	−0.721	−0.392
K_{11}, per million psi	7.899	2.454	1.455	0.984	0.710	...
K_{12}	0.165	0.161	0.181	0.196	0.207	0.221

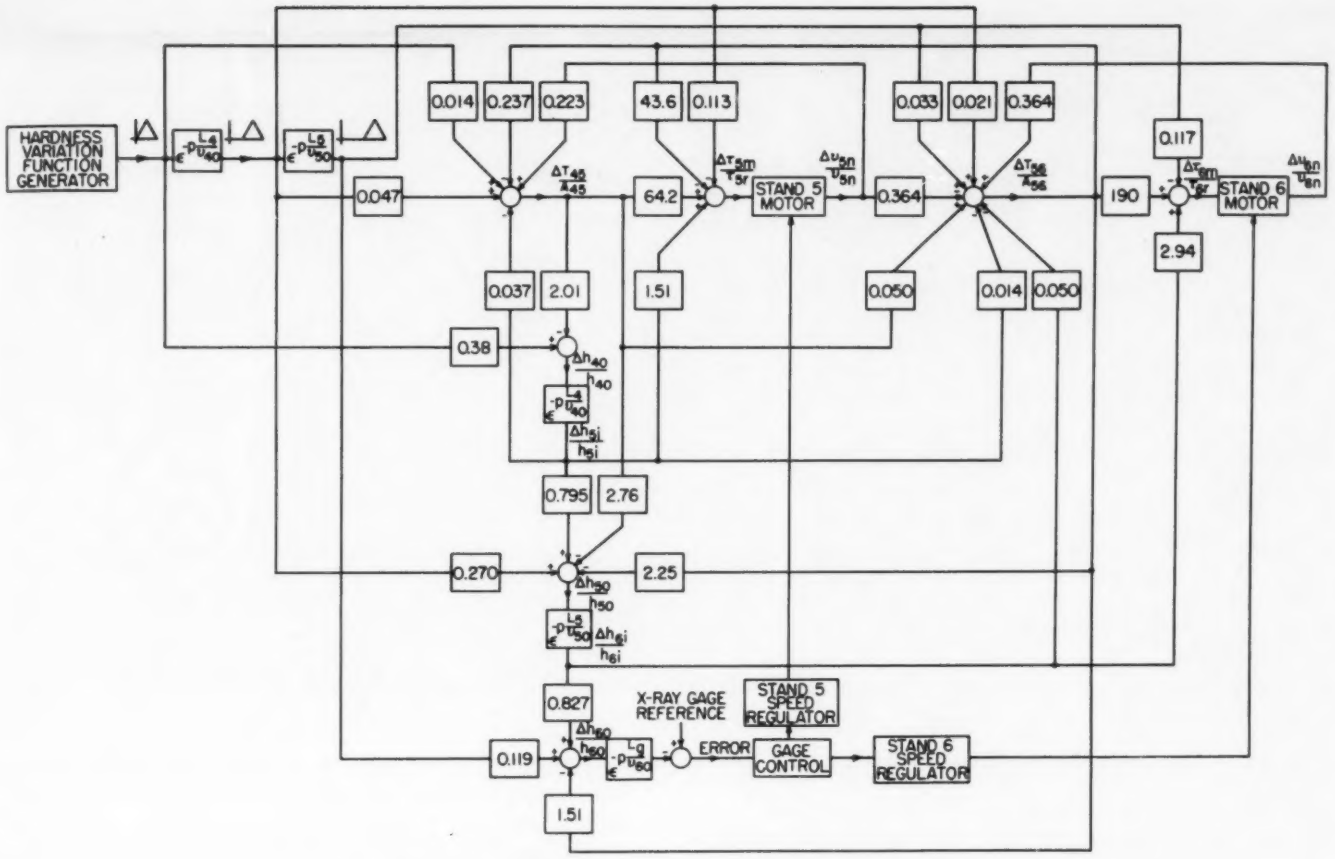


Figure 1 — Block diagram of stands 4, 5 and 6.

$L4/4O$ is the time it takes the hardness variation to propagate from stand 4 to stand 5. The quantity in the block is the mathematical representation of transport delay.

There are four changes produced by this hardness variation as it enters stand 5. First, there is a direct change through the constant 2.70 to affect thickness delivered from stand 5. It also affects tensions between stands 4 and 5, tension between 5 and 6 and the load torque on the stand 5 motor which in turn affects its speed.

The output thickness variation of stand 4 propagates through an identical transport time and becomes the input thickness variation to stand 5 and through this constant affects the output thickness of stand 5. Tension 4 to 5 also affects this thickness through the constant 2.76 and tension 5 to 6 affects this thickness through constant 2.25. In a similar manner the hardness variation propagates to stand 6.

Figure 2A shows the hardness variation passing through stands 5 and 6 with no automatic gage control. Figure 2B shows the effect of using the output of an x-ray gage located six ft from the roll arc of contact on the delivery side of stand 6 to control the speed of the stand 6 motor through its speed regulator. Figure 2C shows the effect of using thickness deviation at the stand 6 roll arc of contact to control stand 6 speed, thus, avoiding the transport delay. Figure 2D shows the effect of using the thickness deviation signal at the stand 5 roll arc of contact to control the speed of the stand 6 motor. Figure 2E shows the effect of using the thickness deviation at the stand 5 roll arc of contact to control the speeds of both stand 5 and 6 motors.

Comparison of these computer runs will reveal the reasons why the vernier control was designed as it was for this application. Comparison of Figure 2C to Figure 2B shows that a much more stable regulator results when thickness deviation is taken from the roll arc of contact rather than from the x-ray gage. Figure 2D is shown to illustrate that even greater stability results if the thickness deviation at the stand 5 roll arc of contact is used rather than stand 6 to control the speed of stand 6. However, overcorrection results in stand 6. Figure 2E shows that the interstand tension needed for control may be spread over two stands and that by proper ratio of the speed changes in stands 5 and 6, the correction needed in 6 to compensate the gage deviation produced there by the hardness deviation may be anticipated. Another conclusion may be drawn from Figure 2E; there would be little benefit from using a second regulating loop sensing thickness deviation at stand 6 and changing the speed of the stand 6 motor. This was actually done as part of the computer study and it was found that the interaction of the two regulators resulted in a greater gage deviation at stand 6 than is shown by Figure 2E.

The computer study resulted in the decision to obtain a deviation signal at the roll arc of contact and use a single regulating loop. There were some gray areas which resulted from the approximations of the computer study. It was felt that the "creep" of the material between stands (which was neglected in the computer study) would introduce additional time into the control loop. Using thickness deviation at the stand 4 roll arc of contact was therefore suggested. Subsequent tests conducted with the installed equipment at the

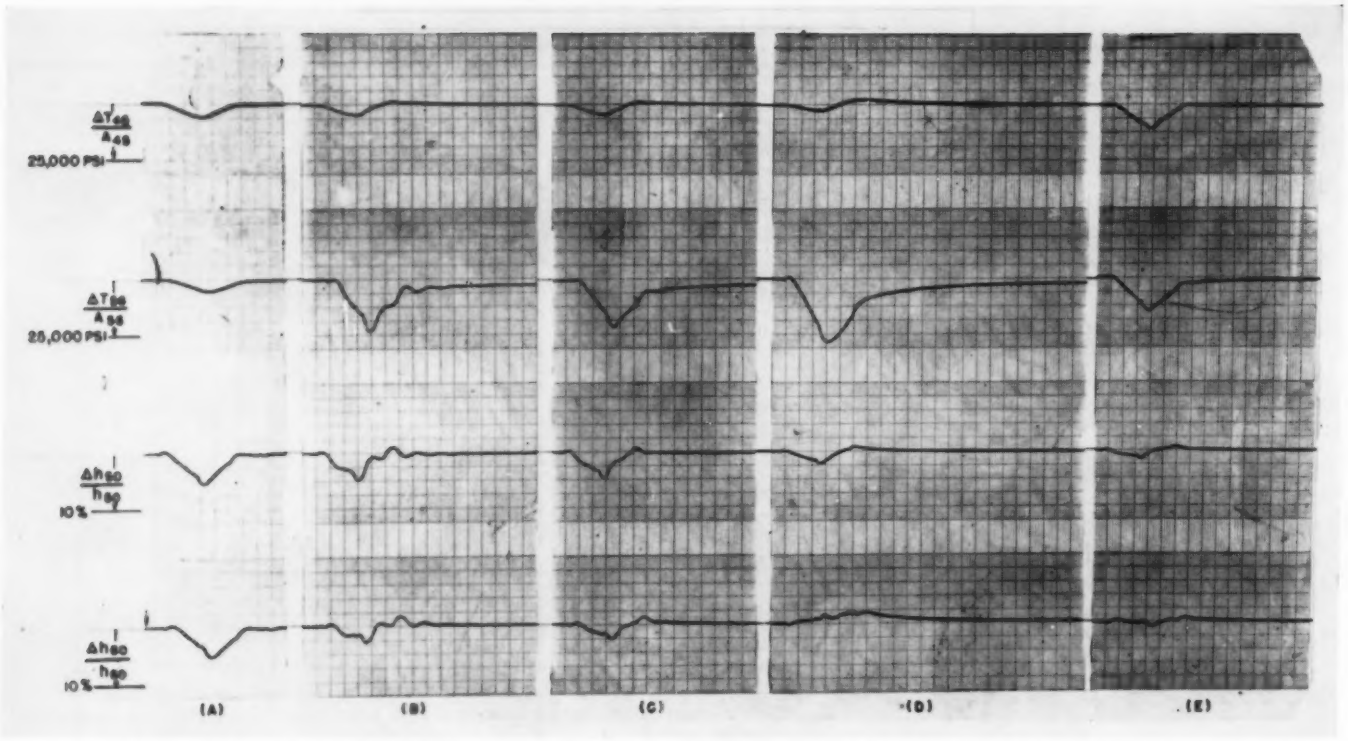


Figure 2 — Measured characteristics of strip going through stands 5 and 6 with and without various combinations of gage control.

Geneva Works have indicated that this is also a good choice. The regulator is presently operating from the stand 4 error signal.

It should not be inferred that it is not possible to represent the entire six stands of the finishing mill on an analog computer. It is just good judgment to keep equipment at the minimum level to accomplish a given job. The job here was to study a vernier control operating on the latter part of the mill.

The type of gage control using tension which has been described in this paper and in the one by Ringger and Koss (4) can become effective only when strip has entered all stands. The regulator usually remains within range until approximately the time the tail leaves stand 2. In order to control gage over a greater portion of the coil, control of gage by the screws of stands 2, 3, 4 and 5 is indicated.

A general description of the electric equipment which was added to the speed-regulated Geneva finishing mill follows. Some of this equipment was based on the computer study, some was based on requirements established previously.

COARSE AND VERNIER CONTROL

The regulating systems subsequently supplied for this hot strip mill, like systems we prefer to supply for five-stand cold strip mills, include a coarse and a vernier regulator.

The coarse regulator (Figure 3) operates screws of stand 2. The vernier regulator, the analysis of which was described, adjusts speeds of stands 4, 5 and 6.

The coarse regulator, in addition to operating screws of stand 2, makes small open loop changes in the speeds of stands 1 and 2 so that interstand tensions 1-2 and 2-3 make minimum departures from their nominally low values.

The vernier regulator (Figure 4) adjusts speeds of stands 4, 5 and 6 simultaneously to regulate constant roll separating force at stand 4. The magnitude of speed change for a given force change is adjusted from experience to obtain good tension distribution 3-4, 4-5 and 5-6.

All stands are equipped with numerical screwdown position regulators having block diagram shown in Figure 5. The output of the error amplifier of stand 2 regulator is used as a measure of departure from any initial screw position. This is the value ΔS_0.

The output voltage of load gages under front and back bottom backup roll chocks of each stand are compared and the difference indicated to show whether the stand is level. The output voltage of the front load gage is also indicated as roll separating force. The output voltage of the back load gage of stand 2 provides a measure of roll separating force to the gagemeter regulator. A small change in this value, scaled for the spring constant of the Geneva mill, is $\Delta F/M$.

Load gage outputs of all stands are differentiated to provide momentary signals as strip enters or leaves each stand, independently of whether rolls are below face. This intelligence is required to time automatic screwdown adjustments progressively between the tail of one strip and the head of the next strip.

A fast-response radiation pyrometer recorder, and recorder-driven sectionalized switch serves to classify incoming bars by temperature range with respect to a mean value; for example, 20 to 40 F high, 40 to 60 F low, etc. As a function of these temperature ranges, a proportional signal is available to cause automatic change of all screws prior to the rolling of the next strip.

A thickness gage and width gage after stand 6 sense deviations from desired dimensions. Width deviations

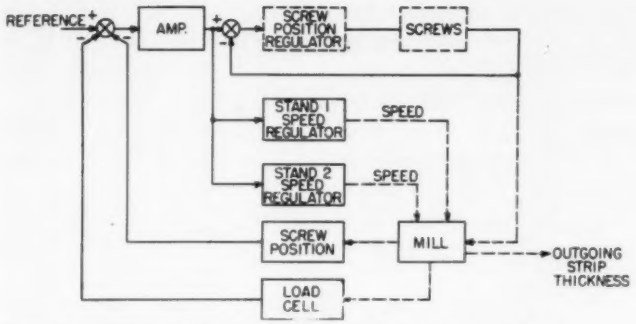


Figure 3 — Block diagram for stand No. 2 regulator.

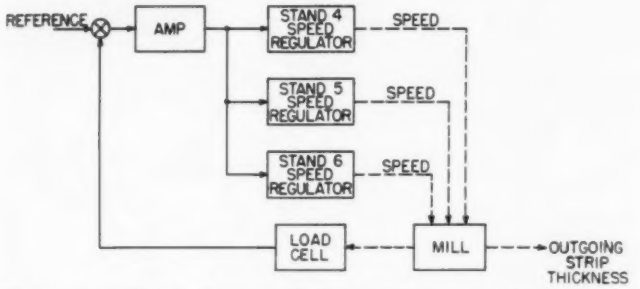


Figure 4 — Block diagram for stand No. 4 reguiator.

are indicated only at present. Thickness deviations are not only indicated but also integrated and averaged. The average deviation is available to cause automatic change of all screws in predetermined proportions prior to the rolling of the next strip of same order.

STAND 2 REGULATOR

The coarse control is a modified gagemeter regulator. Since $h = S_o + F/M + K$ is the basic gagemeter regulator equation, the delta form is $\Delta h = \Delta S_o + \Delta F/M$. To obtain $\Delta h = 0$, ΔS_o is regulated to the value $-\Delta F/M$. A measure of $\Delta F/M$ is obtained by operating a servo-driven potentiometer from a load gage momentarily, as strip enters stand 2, then, during the rolling of the remainder of the strip, subtracting the output of the stationary, disconnected potentiometer and the varying load cell output in a multi-input transistor amplifier.

For example (Figure 6) the load gage under the back bottom backup roll chock of stand 2 produces a voltage proportional to roll separating force which controls a small 60-cycle servo-motor (Figure 7), geared to long-life plastic potentiometers. Arm voltage of one of the

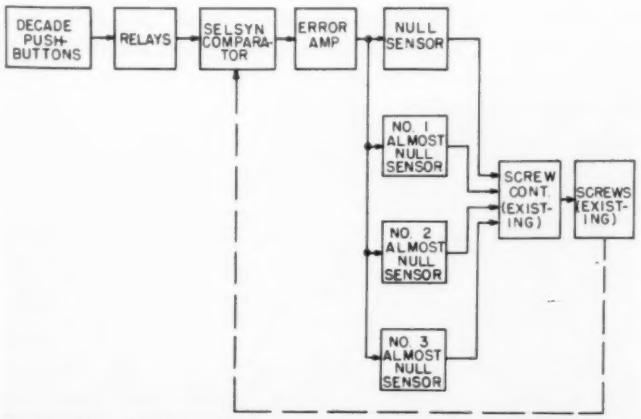


Figure 5 — All stands are equipped with numerical screw-down position regulators.

potentiometers can represent separating force at any instant. Disconnection of the servo supply serves to maintain the value for use as a reference while roll separating force subsequently departs from the reference value.

Provision is made to preset a reference but this requires operator attention. The automatically servo-set reference has been found satisfactory. As used, the absolute value of thickness leaving stand 2 is not established in advance but, within the limitations of magnetic screwdown control, head end thickness is maintained throughout the strip.

The increase in roll separating force at stand 1, caused by increase in yield stress as the strip cools while entering, is measured by a pressure gage and a portion of the signal inserted in stand 2 regulator to reduce the regulated value of roll opening. If adjustable voltage screwdown control were used, it is expected that the resulting taper in thickness, the amount determined by experience, would approximately compensate for the additional spring which occurs in subsequent stands while rolling the colder, harder steel.

Limitations experienced in using existing d-c magnetic screwdown control were anticipated. Available funds were used elsewhere with the knowledge that replacement d-c adjustable voltage screwdown control or electro-hydraulic screwdown control would produce more uniform product leaving stand 2. It was thought advisable to first explore the capabilities of the vernier regulator.

The present coarse regulator may move screws down as a skidmark passes stand 1 or stand 2 but it does not move screws down and up for each skidmark. At present screws move downward only during the rolling of a strip, returning upward between strips. Reduction of thickness variation at skid marks is left entirely to the vernier regulator.

At the left in Figure 8 is stand 2 regulator panel. The assemblies with square covers are the 60-cycle servo-driven potentiometers. Encapsulated transistors and encapsulated plug-in relays are visible.

STAND 4 REGULATOR

Considering again the delta equation, $\Delta h = \Delta S_o + \Delta F/M$, when there is no screw movement $\Delta S_o = 0$ and to obtain $\Delta h = 0$, $\Delta F/M$ should be regulated to zero by the use of interstand tension.

As for the coarse regulator, a measure of $\Delta F/M$ is obtained by comparing pressure gage and servo-driven potentiometer output after the head end of the strip establishes a potentiometer setting.

At the left in Figure 9 is a power magnetic amplifier panel which provides d-c voltages which vary directly

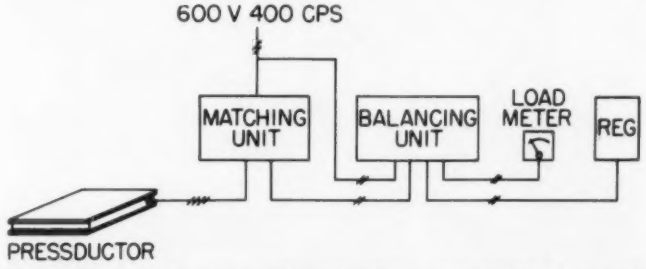


Figure 6 — Load gage produces voltage proportional to roll separating force.

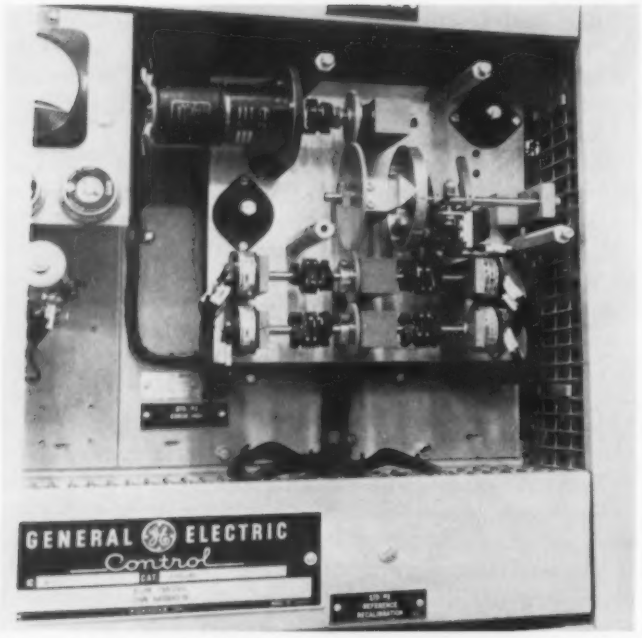


Figure 7 — A small 60-cycle servomotor is actuated by the load gage.

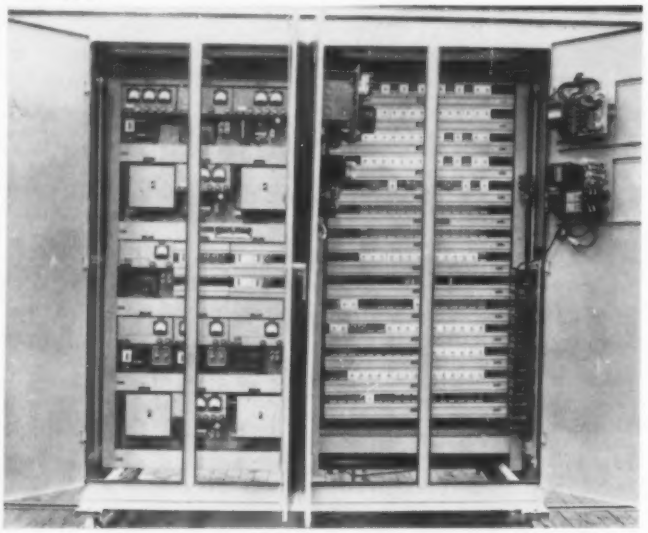
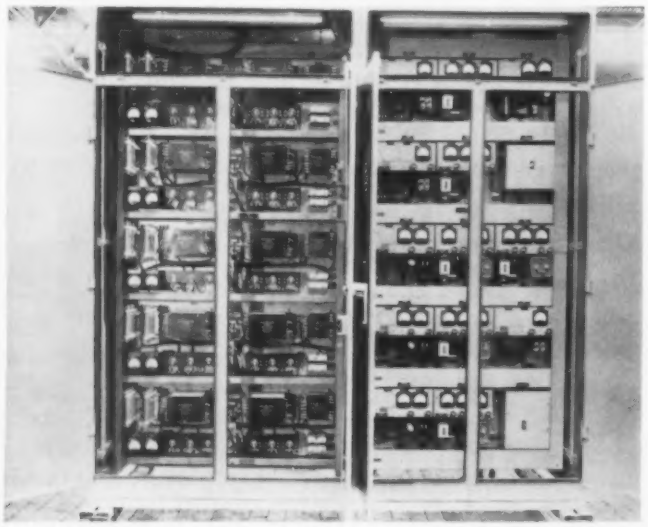


Figure 8 — Gage meter control regulator panel for stand 2 is shown at left; static switching for all stands is shown at right.

Figure 9 — Automatic vernier adjustment of speeds of stands 4, 5 and 6 is one element in the automatic gage control.



with $\Delta F/M$, in preselected proportion. These voltages are a part of the speed regulator reference voltages for the mill motors of stands 4, 5 and 6. The output polarity cannot change. Accordingly each stand operates in a range of speed above that dictated by speed regulator action alone, but will not operate at a lower speed to cause loss of tension and looping.

At the right is stand 4 regulator panel. Plug-in devices and plugged interconnections are used extensively.

The view of the Geneva motor room shown in Figure 10 shows the 600-volt tachometers, geared to mill motors, which provide the feedback for speed regulators on each of the six finishing stands. Fast-acting speed regulators make it possible for the last three stands to decelerate as a skid mark leaves stand 4 without loss of tension during the transient condition.

PRESSDUCTOR PANEL

The panel shown in Figure 11 contains balancing units for ten of the twelve pressure gages. Filter circuits remove harmonics from the a-c output and from the d-c output following rectification. Compensation voltages, adjustable in magnitude and phase, are provided to cancel unbalanced voltage produced by the pressure gages. The filtered d-c voltage is linear within 1 per cent over the working range of compressive force, 300 to 1600 metric tons per load cell. Hysteresis is negligible for large or small changes in force.

For the particular pressure gages used in this control output voltage is roughly proportional to input voltage and is proportional to frequency. To insure constant input voltage and frequency, pressure gages are supplied by a 600-volt, 3-phase, 400-cycle alternator provided with magnetic amplifier voltage regulator and shunt capacitors, and driven by an induction motor.

SETUP CABINETS

Located behind operators, one toward each end of desk, are two setup cabinets, one for first three stands and one for last three stands. The cabinet for stands 4, 5 and 6 is shown. Following a roll change the operator manually rotates a panel-mounted differential selsyn until an indicating voltmeter reads zero, thereby zeroing the numerical screwdown control. These panels also contain selector switches and rheostats for selecting and calibrating temperature compensation, thickness deviation compensation, etc.

Figure 10 — The 600-volt tachometers are geared to the mill motors to provide feedback for speed regulators on each of the six finishing stands.

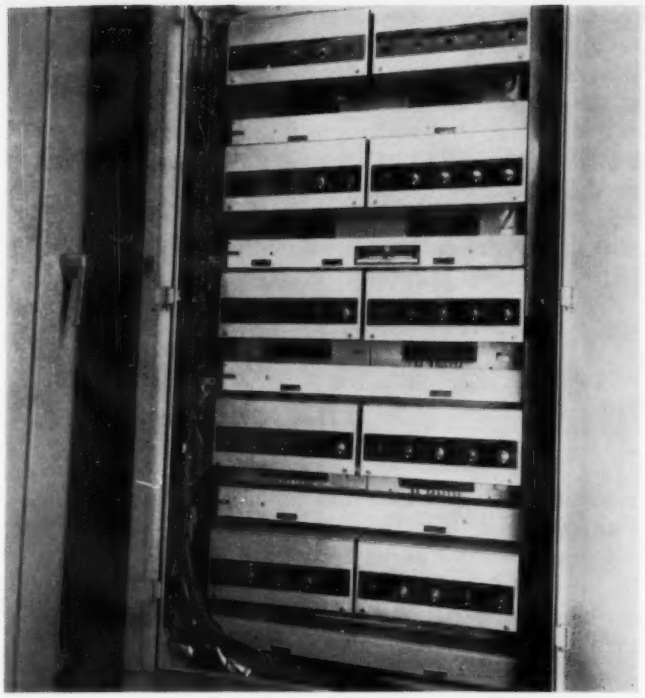


Figure 11 — Balancing units are used on ten of the twelve pressure gages.

The left panel contains the potentiometer recorder which is a part of the temperature compensation circuit, and also mounts a distribution panel and dimmer rheostats for the black lighting and incandescent lighting of the speed pulpit.

Referring again to Figure 8, the right panel contains amplifiers and static switching modules associated with much of the circuit interlocking. It includes a method of storing temperature identification for the two strips that may be in the mill at any instant. One bank of storage relays, A, receives information for an oncoming strip while another bank B, stores information which maintains desired screwdown settings for the preceding strip. As the oncoming strip enters each stand, its screws will have just been repositioned, from information in bank A. Then, during rolling, bank A transfers its information to B and becomes free to receive new information from the next bar.

SCREWDOWNS SET BY PUSHBUTTON

Decade pushbuttons for presetting two of the six screwdowns, those for stands 4 and 5, are visible in the foreground of Figure 12. These operate encapsulated relays on doors of numerical screwdown

Figure 12 — In foreground can be seen decade pushbuttons for part of the numerical screwdown positioning control.

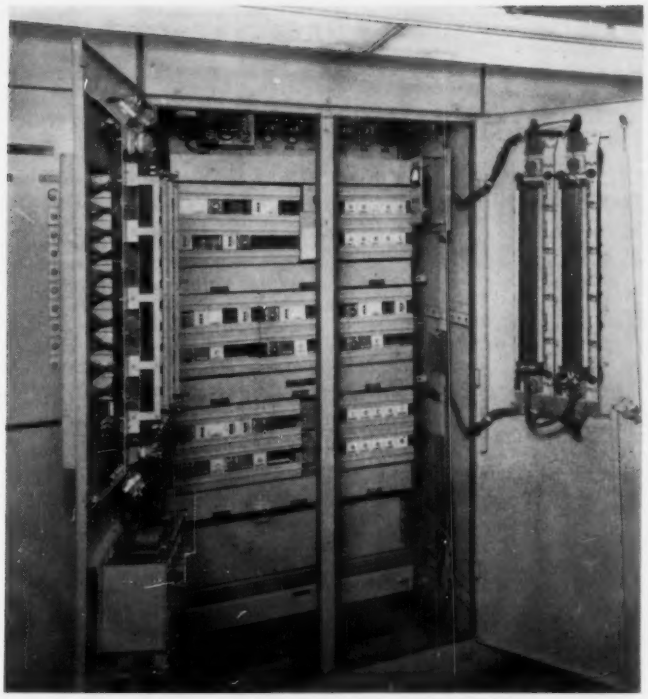


Figure 13 — Numerical screwdown positioning control for stand 3 of 6-stand hot strip finishing mill.

control cabinets (Figure 13). These relays select taps on a transformer secondary to simulate, without rotating devices, the position of a selsyn transmitter. The transformer is located below relays on door. Feedback selsyns are driven from worm shaft of the front screwdown of each stand. The range of the position regulators is 0.000 to 4.500 in.

SUMMARY

The thickness regulators have performed in accordance with predictions made as a result of the analog computer studies. The location of control panels in the expanded speed pulpit to enable direct observation of the mill during adjustment and servicing is important. Some features provided are not as yet fully evaluated. The vernier regulator has met all expectations and is especially useful when rolling the thinner product intended for cold rolling to tinplate. It functions over the greater part of strip length but is, of course, limited to the portion where tension can be applied.

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Dr. R. B. Sims: Messrs. Maxwell and Phillips have given us, in this paper, a most interesting insight into the design study which they undertook with the United States Steel Corp. engineers for the first hot mill gage control at Geneva, Utah. It demonstrates clearly the complexity of the control engineering for automatic gage control on hot mills. Indeed, the detailed engineering is a great deal more involved even than this article would suggest.

One of the most difficult things about engineering a control system for a hot mill is that comparatively little is known about the mathematics of hot rolling. Orowan's (5) analysis for the calculation of roll force and torque is not readily applicable, and its simplification assuming sticking friction (6) throughout the arc of contact is not necessarily exact. The Research and Development department of my company is carrying out a study on this subject on production mills, and it would seem that the assumption of sticking friction throughout the arc of contact gives results which are accurate to about the 10 per cent level for load calculations, but in the lower temperature range it would seem that calculation overestimates somewhat the value of torque. The calculation of roll force and torque in hot rolling, however, is not sufficient for the design of a control loop, and laboratory studies on the hot rolling process have not been undertaken so far, probably because they are expensive projects to undertake.

Parameters on which exact information is still necessary are, the effect of tension on forward slip, the effect of tension on roll force and torque, and the yield stress of hot metal as it passes from one stand to another. While many hot mill engineers will consider that forward slip is a quantity of no great practical importance, nonetheless it provides the greatest single stabilizing force in a gage control loop and some idea of its magnitude is essential in any process which seeks to apply tension to hot material. Again, little work has been done to give information on yield strength of material between the stands. The characteristics of the hot metal between the rolls is now well understood (7), the work carried out in the British Iron and Steel Research Association laboratories has shown that hot material work hardens considerably, but information obtained so far gives no idea how quickly this work hardening effect disappears, and consequently we have no idea of the yield stress of the metal midway between the stands. There is no doubt that material when it leaves a mill contains a certain amount of residual work hardening, which probably disappears as the metal approaches the second stand. On the other hand the yield stress will tend to increase because of the fall in temperature with time, so that there probably exists, at some point ahead of the stand, a zone of minimum hardness of the metal, and it is there that necking will take place in the strip if tension is applied to it. Clearly, therefore, it is essential to know the location of this zone of minimum strength and the value of the yield stress there in order to calculate the maximum tension which can be applied to the strip for control purposes.

The effect of tension on rolling load and torque may be calculated. This can be shown to be:

$$F = F'' - \frac{\sqrt{R'\Delta h}}{h}\,[(1 - \psi/\alpha)T_i + (\psi/\alpha)T_o]$$

where the notation is that of the paper by Maxwell and Phillips and F'' = load at zero tension, lb, R' is the deformed roll radius in. Δh = the drafting of the strip, in. α = the angle of entry, and ψ = the angle of the neutral plane. A similar equation can be derived for torque. The equations to $\Delta F/F$, $\Delta\tau_r/\tau_r$ and $\Delta h/h$ given by the authors in their paper will, therefore, have more meaning when additional research has been carried out to give practical values to the various constants K_1 to K_{12}.

The original gagemeter equation (8) when it was discovered in 1949 was given the differential form used by the authors but subsequent research work has pointed to the fact that this is not the most economical method of using the information. Work carried out in the writer's laboratory indicates that an equation in the form $\pm \epsilon = (F/M) + S_0 - h'$ where h' is the required thickness and ϵ is the gage error, is of greater utility since firstly the equation gives a direct reading of the strip thickness which can be useful in practice, and moreover a control form can be devised in which the gage can be controlled by tension between bounds of upper and lower limits, and then the applied tension can be reset by the mill screws to a mean value when one of these limits has been reached (9). This gives the control form, in effect, an infinite range of control which is not the case with the installation described in this paper.

H. S. Maxwell and R. A. Phillips: The authors agree with Dr. Sims that further research into hot rolling should be undertaken along the lines he suggests. We are particularly indebted to the British Iron and Steel Research Association for the large amount of study already carried out by them.

Dr. Sims implies that the calculation methods now available are not sufficient for the design of control loops. Here we must disagree both philosophically and practically. From a philosophical standpoint, as control systems engineers, we know that the principle of feedback control makes it possible to build regulators for processes about which knowledge is insufficient for open loop control. From a practical standpoint, we cannot afford the luxury of waiting for further research. The age of automation of the steel industry is upon us and we must move extremely fast or be left behind.

It should be remarked in passing that this first installation met our expectations. That we are not alone in this opinion is evidenced by the fact that almost all new hot strip mills in the United States are being equipped with automatic gage control. ▲

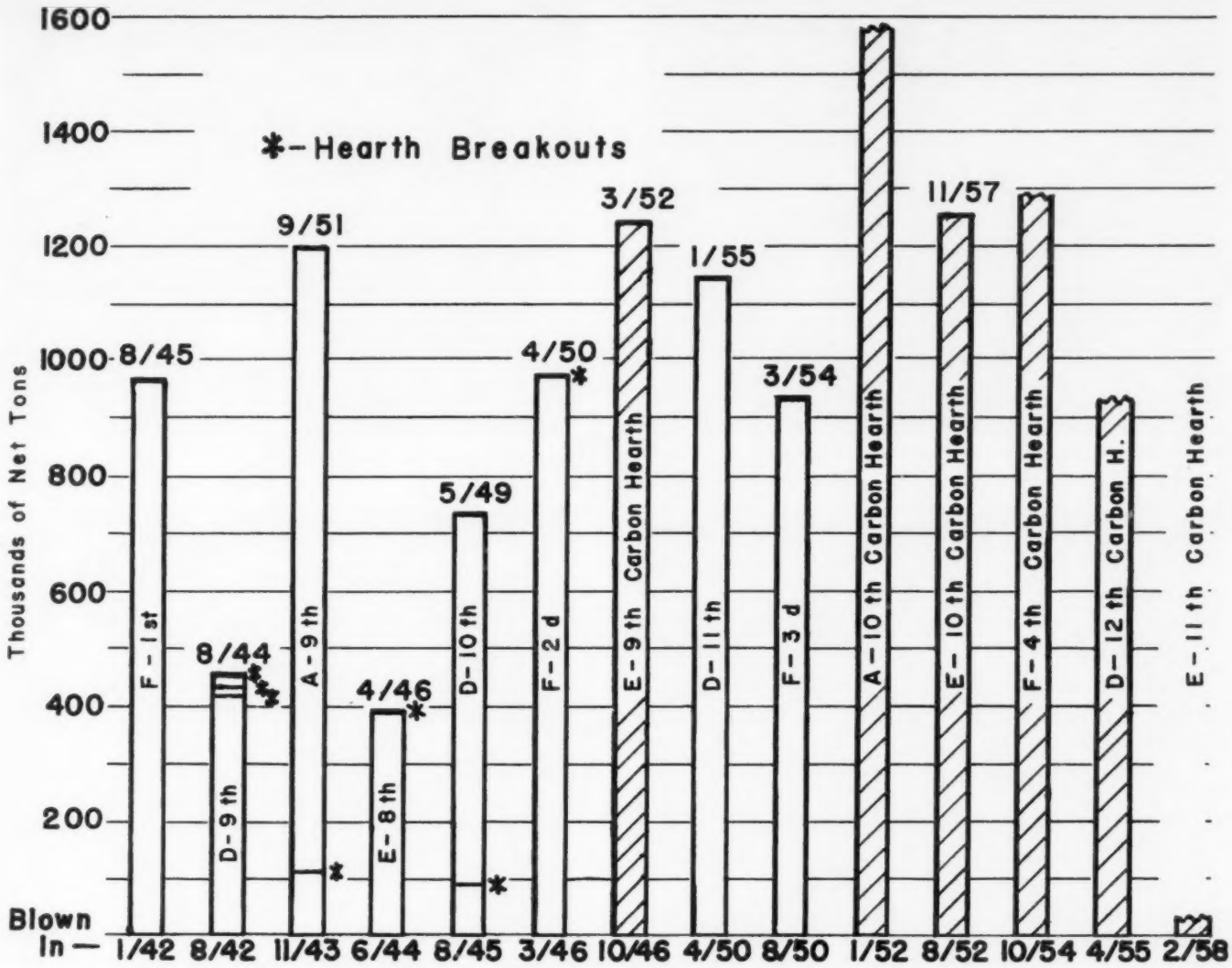

Figure 1 — Lining tonnages of furnaces at the Pueblo plant are given in this figure.

Improved Blast Furnace Lining Life at Colorado Fuel and Iron Corp.

By JOHN W. CARLSON, Superintendent
A. E. FREY, Practiceman
and D. MALWITZ, Practiceman
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Through constant attention to detail and continuous study of furnace performance, lining life of the blast furnace has been markedly increased.

BLAST furnace linings at CF&I's Pueblo plant, Colo. during the past decade have produced more than twice the tonnages than in a similar period prior to that time. Lining histories of the four present furnaces dating back to 1900 show that up to the 1940's there had been 27 linings. Only two of these produced over one million tons; both required shutdowns for patching during their campaigns to achieve the million-ton total.

The other 25 linings failed on tonnages between 70,000 and 900,000 net tons, with an average of approximately 500,000 net tons of iron produced. These figures do not include the 18 or so linings on three earlier stacks.

In the mid-1940's the furnaces were plagued with a series of hearth breakouts. The furnace linings during

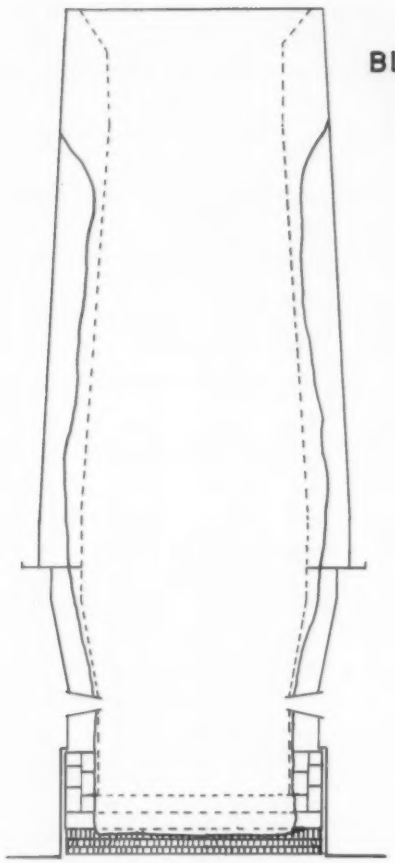

Figure 2 — Typical section shows that entire throat is practically gone.

that period (see Figure 1) may be summarized as follows:

May 20, 1944 "D" Furnace, 9th lining, broke out through the hearth at 420,149 N. T. (net tons). It was patched and put back in production.

May 24, 1944 "A" Furnace, 9th lining, broke out below the hearth coolers at 109,628 N. T. This was an old bottom of undetermined tonnage. A new hearth and bosh were installed.

July 3, 1944 "D" Furnace, 9th lining, iron came up through column. It was patched.

Aug. 28, 1944 "D" Furnace, 9th lining, broke out through hearth and columns at 458,132 N. T. It was blown out. Days operated: 747. Average daily tonnage: 613.

Aug. 13, 1945 "F" Furnace, 1st lining, had a hearth failure at 965,877 N. T. Days operated: 1292. Average daily tonnage: 747 N. T.

Jan. 11, 1946 "D" Furnace, 10th lining, broke out through hearth at 95,588 N. T. It was stub cooled and run as a "cripple" with the two tuyeres over the breakout blanked during the remainder of its campaign.

April 3, 1946 "E" Furnace, 8th lining, broke out through hearth at 394,183 N. T. It was blown out. Days operated: 648. Average daily tonnage: 650.

At that time, in 1946, in an effort to stem the rash of hearth failures, carbon was selected for relining the hearth in "E" for its 9th lining. This was one of the early installations of carbon in a blast furnace in the

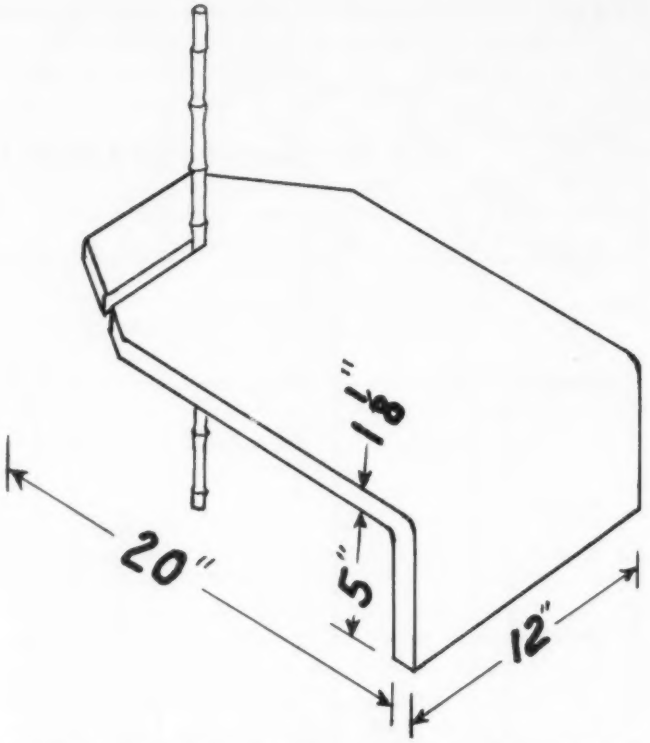

Figure 3 — Blast furnace throat armor is made from rolled plate.

United States. The lining consisted of two courses of 22½-in. blocks on the hearth bottom for a total of 45-in., with two rows of 15-in. thick hearth wall blocks for a total of 30-in. thickness. Vertical joints in the bottom and between the two rows of wall blocks were filled with 2 in. of carbon ramming mix. The 3-in. space between the hearth wall and the cooling plates was filled with sized coke breeze. The hearth wall extended up the height of the hearth cooling plates, which was 15 in. below the centerline of the cinder notch. Conventional ceramic brick was used in the bosh and stack of the furnace. This lining was blown in Oct. 24, 1946.

Figure 4 — View of hearth shows that much of the blocks is gone.

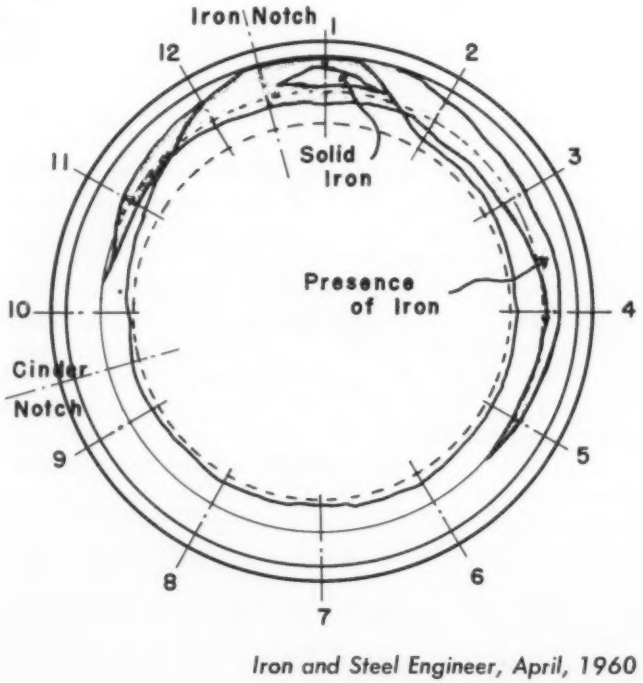

Figure 5 — Hearth wall blocks here are located under tuyeres No. 5, 6, 7.

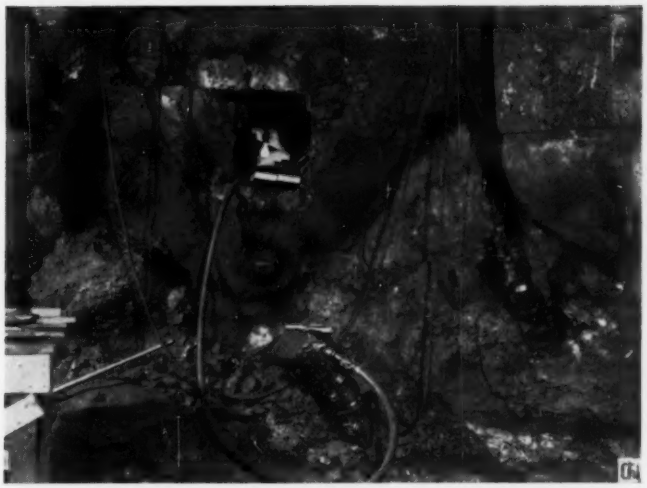

Figure 7 — In iron notch section iron is seen to the right and below the notch.

Figure 6 — Hearth wall blocks were in excellent condition.

Figure 8 — Iron was found under tuyere No. 1.

Referring again to Figure 1, the summary of linings continues as follows:

May 7, 1949 "D" Furnace, 10th lining, which had been running as a "cripple" was blown out at 737,139 N. T. Days operated: 1374. Average daily tonnage: 538.

April 3, 1950 "F" Furnace, 2nd lining, broke out in hearth at 976,148 N. T. It was blown out. Days operated: 1471. Average daily tonnage: 664.

Sept. 30, 1951 "A" Furnace, 9th lining, blown down for relining and enlarging at 1,180,825 N. T. Days operated: 2606. Average daily tonnage: 461. Entire lining was in fair condition.

Mar. 16, 1952 "E" Furnace, 9th lining, first carbon hearth, upper inwall failure at 1,241,728 N. T.—a record tonnage at that time. It was blown out. Days operated: 1970. Average daily tonnage: 631.

The 9th lining of "E" Furnace was carefully examined during the clean-out because of the record tonnage it had produced and also because it included the first carbon hearth at this plant. The furnace showed evidence of failure seven months earlier in the area below the stock line wearing plates. At that time external cooling was applied to the shell. No stack cooling plates are used at the plant.

During the clean-out, it was seen that the entire throat section was gone and the furnace was running on the shell as shown in Figure 2. This condition was far worse than had been anticipated—the most complete stack failure ever experienced by these furnaces.

Other throat failures prior to this showed the need for a different type throat armor. Before 1950, a cast iron block with arms tying back into the brick was used. The block would work loose and eventually pull the brick with it as it fell into the burden. Starting in 1950, rolled steel plate, formed as shown in Figure 3, has been used as throat armor. The idea behind this new plate armor was that the brick would be fully protected until the face section of the plate wore away, and even then the brick would get some additional protection from the remaining horizontal plate between the courses of brick.

The plates are firmly anchored by reinforcing bars slipped into slots at the rear of the plate. The reinforcing bars are tied together vertically and horizontally and lumnite cement (in place of the middle row of brick) is poured around them.

Continuing with the examination of "E" Furnace, the inwall and bosh sections were typical of a well-worn furnace lining. In the hearth, excluding the area about the iron notch, the carbon in the upper hearth wall was in excellent condition. The lower portion of the hearth wall was somewhat eroded but to a depth not exceeding 10 in. The two courses of carbon across

the bottom and inside the hearth walls had gone, and some of the top course of the underlying ceramic brick had been eroded. The ends of the horizontal carbon blocks (stubs) remaining under the hearth walls were irregular in shape and approximately flush with the hearth walls.

At the iron notch section, and between tuyeres No. 11 and No. 2, virtually all of the inside row of blocks and much of the outside row of blocks were gone (Figure 4). Under tuyere No. 1, some two feet below the iron notch, iron had come in contact with the hearth cooling plates and was solid enough in its structure to indicate that it had been active. In either direction away from the iron notch, the presence of iron was indicated between the rows of wall blocks for a total distance of about half the hearth circumference. In the active iron area the front of the furnace was covered with a large mass of kish and slag.

Figure 5 shows the hearth wall blocks and the bottom block stubs under tuyeres No. 5, 6 and 7. Figure 6 shows the excellent condition of these wall blocks as they were removed from the furnace. Figure 7 is of the iron notch section and indicates the active iron area to the right and below the notch. Figure 8 shows the piece of iron lying under tuyere No. 1 and the extent to which it had "finned" up and out.

The following is quoted from a report on this lining written in 1952 by the blast furnace superintendent at that time: "It is simply a matter of theorizing to account for the loss of carbon in this 'E' Furnace hearth: at no time during the campaign did the furnace manifest a decided change in its operation that could be attributed to disintegration of that portion of the hearth that took place during the campaign. It would, therefore, not be possible to determine the rate at which the partial disintegration took place. I should say that it was fortunate that the furnace operated as long as it did without suffering serious difficulties. In other words, with active iron next to the coolers it was a matter of chance that it did not go through the cooling elements; but, here again, this may be one of the advantages of carbon as a hearth lining material . . . . We feel sure that anything that held up as well in the upper hearth wall areas as this carbon did at least has possibilities for continued use as a blast furnace refractory."

Indeed, even before this lining was blown out, its improved performance was cause for carbon to be installed in the hearth of "A" Furnace, 10th lining, which was blown in January 17, 1952. The bottom of the hearth in "A" consisted of two courses of blocks, each 28½ in. thick. This lining is still in production and, as of April 1, 1959, had produced over 1,580,000 N. T. —a record for CF&I.

In the spring of 1952, reports of iron notch troubles in blast furnaces using carbon hearths coupled with the observation of the iron notch on "E" spurred a search for a better tap hole mix. This resulted in the use of a tar-mixed material in place of the water-mixed material used up until that time. The tap hole procedure will be discussed later in this paper.

Following the success of the 9th lining on "E," the 10th lining also included a carbon hearth. The bottom this time was made of two courses of *machined* and *keyed* carbon blocks, each course 28½ in. thick, with the blocks cemented and fitted together as tightly as

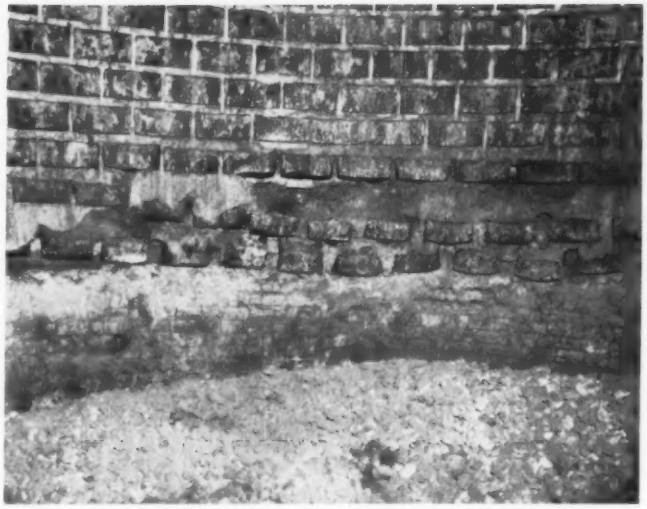

Figure 9 — Armor and bricks at throat were damaged but still in place.

possible. The hearth walls were two rows of large carbon blocks, each row 15 in. thick, with 2 in. of rammed mix between rows and 2 in. of rammed mix between the cooling staves and the outside row of blocks. The top of the carbon was raised to 2 in. above the center line of the cinder notch. The bosh was lined with 27 in. of ceramic brick and had 24 in. cooling plates. The stack was lined with 18 cone brick, 45 in. thick. This lining was blown in August 4, 1952.

Continuing briefly with the summary of lining performances (refer again to Figure 1):

March 1, 1954 "F" Furnace, 3rd lining, blown out at 938,028 N. T. Days operated: 1279. Average daily tonnage: 733. No hearth breakout, but kish was against plates.

Jan. 10, 1955 "D" Furnace, 11th lining, blown out at 1,145,496 N. T. The last three months of the campaign was on ferromanganese. Days operated: 1735. Average daily tonnage: 660 N. T. No hearth breakout, but lining was worn out. Kish was against hearth plates.

Nov. 30, 1957 "E" Furnace, 10th lining, banked at 1,254,439 N. T.—a record at that time. It was later cleaned out and relined. Days operated: 1735. Average daily tonnage: 720.

In October of 1957, "A" was banked. Then in November, 1957, "E" was banked. At that time "F" had over one million tons on its lining, and "D" had about three-quarter million tons. Foreseeing the possibility that at a later date two or more furnaces might have to be down for a reline at the same time, it was decided to try to take pictures of the inside of the banked furnaces for clues as to the wear on their linings.

A wooden crate was made to hold a press-type camera. The crate and camera were lowered through the big bell inspection door, past the opened big bell, down to the approximate level of the stock line. Trouble was experienced in synchronizing the flash and shutter since the flash was fired through a long extension cord from the top platform. This was overcome by using the regular synchronized flash unit on the camera. A separate power source, at the top, feeding through an extension cord, tripped a solenoid on the camera shutter.

Figure 10 — In "E" furnace there were only six courses of the original 19 courses of armor left.

Figure 12 — Iron notch is shown after removal of tap hole mix build-up.

The pictures inside "A" showed the armor and bricks were damaged but still in place (Figure 9). The pictures inside "E" showed that around most of the throat there were only six courses of the original 19 courses of armor remaining and the brick and cement behind the armor were missing (Figure 10). From these photos it was decided that "E" was in the worst condition. New bells were installed in "A," and she was blown in from bank in March 1958.

Meanwhile, "E" was being prepared to be cleaned out for a more complete inspection inside the furnace. The top was removed and a hanging scaffold installed. A section was cut through the bosh and a coal mining "duckbill" placed through this opening to remove the burden from the furnace. The condition of the throat section of the lining was as expected from the photographs. The remainder of the stack lining and the bosh were well worn but not in critical condition. The upper part of the carbon hearth side walls were in virtually new condition. The lower part of the side walls were gradually eroded to a maximum of 8 in. (Figure 11). The bottom courses of carbon were cut in the expected "saucer" shape through the top course and into the bottom course approximately 8 in.

The most surprising thing in the furnace was the excellent condition of the tap hole section. A build-up of fused tap hole mix completely covered the hot face of the iron notch. This buildup was as much as two

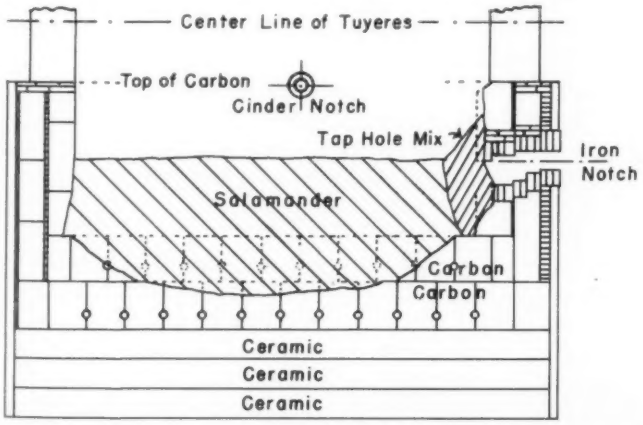

Figure 11 — Hearth and salamander for tenth lining of "E" furnace.

feet thick and tapered off several feet all around the tap hole. The inside face of the carbon, which had been 9 in. thicker than the rest of the carbon to begin with, had worn back about 6 in. The brick lining of the tap hole itself showed some disintegration and replacement with fused mix at the iron face, but several inches back the brick was in near-new condition (Figure 12).

The first carbon block clockwise from the iron notch showed signs of earlier iron erosion but was now patched with fused tap hole mix. A thin fin of iron ¼ in. thick and 12 in. high, was between the two side rows of carbon. It extended from the iron notch counterclockwise nearly to the cinder notch. A horizontal plate of iron, up to 1 in. thick in the center, underlay the bottom course of carbon blocks and covered about half the area of the hearth.

It was felt by the blast furnace personnel that this hearth would have lasted many more months. However, for several reasons, it was decided to reline the furnace: first, to protect themselves against the risk of losing several old linings at the same time; next, install new equipment and make alterations to improve this furnace; lastly, do all this while the demand for pig iron was low.

While relining "E" in 1958 (its 11th lining), the hearth was altered to allow enough depth for three 28½-in. courses of carbon in the bottom. The side walls were made of two rows of 9-in. carbon brick and one row of 13½-in. carbon brick. The hearth diameter was enlarged 9 in. This lining was blown in February 1, 1959.

Following the series of hearth breakouts in the 1940's, closer attention was paid to the tap hole practice. A careful study was conducted to improve the physical properties of the tap hole area. Of many ideas discussed and tried, probably two developments were essential in increasing the physical stability and life of the tap hole area of the hearth. They were the construction and use of a drilling jig in 1947 and use of carbonaceous tap hole mix in 1952.

Prior to the introduction of the drilling jig, the drill was guided manually. Seldom were there two identical tap holes. It is reasonable to assume that the multiple positioned tap holes would result in a large volume of "green" mix in the tap hole area, thus making this

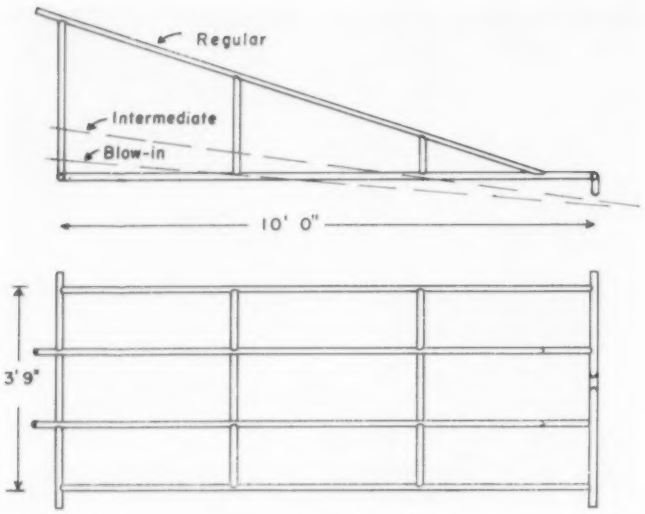

Figure 13 — A drilling rig guarantees that each hole is drilled in the same manner.

Figure 14 — Drilling machine was made by modifying a wagon drill.

area avid to iron erosion and general hearth failure.

The drilling jig shown in Figure 13 assures that each hole is drilled from the same position and at a constant angle. The jig is set in four dogs which are bolted to the cast iron runners set into the floor during furnace rebuilds.

Incidentally, during the past six months, in the interest of safety, a remote control drilling machine has been used experimentally. This was constructed by mounting the boom from a wagon drill on a modified drilling jig (Figure 14). The controls are placed permanently at one side and several feet away from the tap hole. Air hoses with quick-connect fittings lead from the controls to the jackhammer and the feed motor on the boom. The whole device is kept overhead out of the way when not in use.

As mentioned previously, investigation into the use of carbonaceous tap hole mix began early in 1952. At that time, United States Steel Corp. at Gary was conducting tests of a carbonaceous stopping mix. Lone Star Steel was using such a mix regularly. Blast furnace personnel visited those plants to collect information on the mixes. Consultation was also made with the supplier.

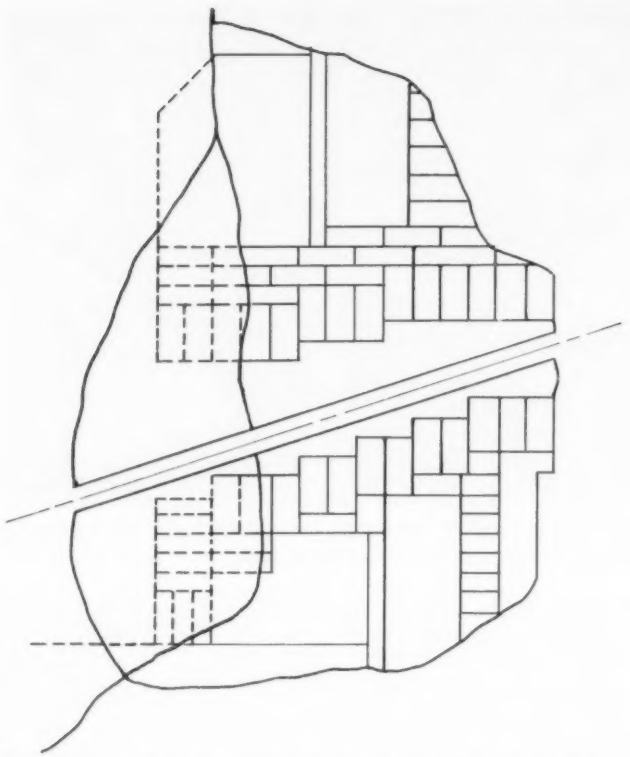

Figure 15 — The view of tap hole shows ceramic build-up and excellent condition of brickwork.

Subsequently, experimental mixes of local clay and ganister and coke plant tar were prepared. These were tested by baking in large diameter pipes and drilling through them. "A" Furnace was selected for a trial run. This initial trial was satisfactory and the use of the tar-clay mix has been continued with adjustments being made in mix composition and handling practices as experience dictates.

Originally, the tar-clay tap hole mix was developed to eliminate water from entering the carbon hearth; however, several unpredicted advantages resulted. While the furnace is casting, the hole does not enlarge to any appreciable extent. The flow of hot metal remains very nearly constant throughout the cast and wild casts have been eliminated. At times, the presence of alkali compounds, locally called "buckwhalen," used to cause much difficulty while drilling in the tap hole. They are easier to drill through with the tar-clay mix. The better control in tap hole practice on the two furnaces with carbon hearths at that time resulted in the mix also being used on the two ceramic-hearth furnaces.

The effectiveness of the tar-clay tap hole mix was confirmed in the spring of 1958 when "E" was cleaned out after having been banked. By carefully test drilling and removing the salamander, the advantages of the tar-clay tap hole mix were obvious. Figure 15 is a sketch of the tap hole as it was found. Comparing this sketch and Figure 12 with Figure 7 shows the marked improvement from the use of the carbonaceous tap hole mix.

Another comparison of the tap hole mixes is the length of the holes drilled. Figure 16 shows that during September, 1947, when accurate records were first being taken for the study of tap hole practice, the average length of the hole was 37 in. This short length

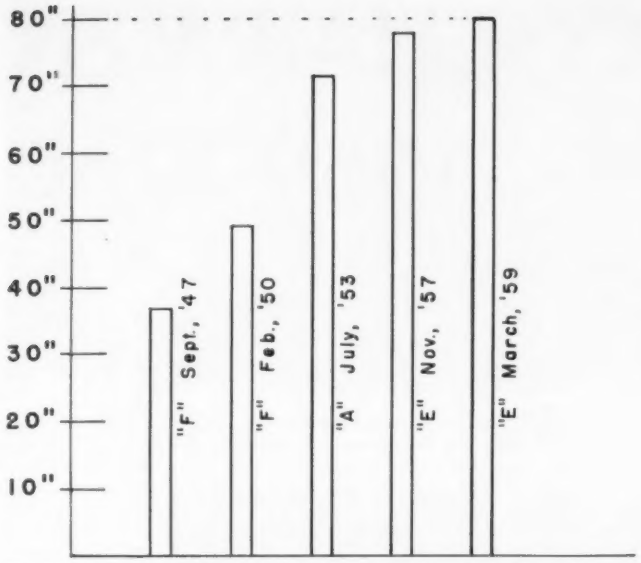

Figure 16 — Length of tap holes is indicative of erosion.

Figure 17 — This fused piece of tap hole mix was removed during a clean-out of "E" furnace in 1958.

indicates that the inside face of the hole was eroded.

"E" Furnace during November, 1957, which had been using carbonaceous mix for all its campaign except the first six months, had an average length of 78 in. More recently, "E" had an average length of 80 in. during March, 1959. This is the maximum desired length, a longer hole could be maintained easily by using more of the capacity of the mud gun.

These long holes clearly indicate a protective covering on the inside face of the tap hole. Figure 17 shows a piece of fused tap hole mix that was removed from inside "E" during its clean-out in 1958.

All of the furnaces at the Pueblo plant now have carbon hearths extending up to approximately the center of the cinder notch. The next reline on "A" will have carbon on up to the mantle.

There is satisfaction in the blast furnace department with the greatly improved lining life of the furnaces. Part of this improvement is attributed to more careful construction, part to better ceramic brick in the stack and bosh, part to the carbon hearths, and part to improved tap hole practices.

As of today, "A" furnace is almost 7½ years old on this lining and has produced more than 1,580,000 N. T. of iron—a record for CF&I. "D" furnace is four years old and has produced more than 930,000 N. T. "E" furnace was blown in February 1, 1959, and has made 35,000 N. T. "F" furnace is 4½ years old and has made over 1,200,000 N. T.—a new record for her. The furnaces are all respectable "Ladies." ▲

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AISE DISTRICT CHAIRMEN 1959-1960

JOHN R. HUNT was born in Cedartown, Ga., but early in childhood moved to Birmingham and attended Birmingham public schools. Mr. Hunt entered the employ of Tennessee Coal & Iron Div., United States Steel Corp. in 1926 as a messenger in the accounting dept., Ensley Steel works. He attended Birmingham-Southern College, graduating in 1931 with a bachelor of science degree in chemistry. He later took postgraduate work at Birmingham-Southern and the Birmingham center of the University of Ala. While attending college he held various positions in the Ensley and Fairfield plants. After graduation he was made supervisor of water treatment in the steam engineering dept. holding that position until 1936. He then was transferred to the Ensley blast furnace dept. as senior practice man, and advanced to assistant superintendent of blast furnaces in 1938. He was made superintendent of blast furnaces, Holt, Ala., during World War II, and returned to Ensley as assistant superintendent of blast furnaces in 1944. In 1948 he was made assistant to the manager of industrial relations, was transferred back to operations in 1949 as assistant to the general superintendent of the Fairfield Sheet and Tin Mills. He was promoted to superintendent of the Fairfield Sheet Mill and in 1951 was promoted to the assistant general superintendent of the sheet and tin mills. In 1954 he became general superintendent of the Fairfield Tin Mill and later advanced to his present position as chairman of operating committees, TC&I Division.

R. D. HINDSON was graduated from McMaster University with an Honour degree in chemistry and geology. He has since been associated with The Steel Co. of Canada for almost twenty years in various metallurgical capacities. At the present time he is assistant chief metallurgist of all works of The Steel Co. of Canada, Ltd.

ROBERT J. GARMY, a native of Canton, Ohio, started in 1937 in the electrical maintenance and construction department of Republic Steel Corp.'s central alloy district, Canton, Ohio. Mr Garmy served four and one-half years with the Navy during World War II. In 1947, he was appointed electrical engineer with the central district and in 1956 was made assistant chief engineer. In May, 1959, Mr. Garmy was temporarily assigned to the new hot strip mill project in Republic's Warren district.

ELMER O. KRUEGER, a native of Illinois, attended public schools in Illinois and Florida. In 1925 he started working for Acme Steel Co. as an electrician's helper, advancing to a motor inspector and hot mill motor room operator. In 1942 he became the electrical maintenance night turn foreman, in 1946 was made foreman, electrical construction and repairs, and in 1956 was named to his present position of general foreman, electrical construction and repairs.

WILLIAM P. SMITH was born in Pittsburgh, Pa., and attended schools in that vicinity. He attended the University of Pittsburgh and graduated in 1941, receiving a bachelor of science degree in electrical engineering. He entered the employ of the General Electric Co. first, engaging in the design of locomotive and mill motors. In 1947 he was transferred to the steel mill application engineering group. In 1952 Mr. Smith joined the Jones & Laughlin Steel Corp., Aliquippa works as electrical foreman in the tin mill. In 1953 he was made general foreman, maintenance, tin mill, and in 1955 was named general foreman, maintenance, south mills. Later in 1955 he was transferred to the Cleveland Works division as assistant works manager, which position he now holds.

HAROLD V. GUMMA was born in Denver, Colo., and educated in the Denver school system. He attended the Colorado School of Mines recieving his degree in metallurgy in 1937. He joined the Colorado Fuel and Iron Corp. as metallurgical assistant shortly after college graduation. In 1940 he was transferred to the mechanical department as turn foreman at the shell forging plant, and in 1941 was named general foreman of this plant. After the shell plant was closed, Mr. Gumma was transferred to the industrial engineering dept., then entered the rolling mills as turn foreman. In 1947 he was promoted to general foreman, rolling mills, and in 1950 was appointed to assistant superintendent, rolling mills, which position he now holds.

J. L. LAIDLAW was born in Glasgow, Scotland, and received his education in Glasgow. He attended Royal Technical College, Glasgow, recieving a degree in mechanical engineering. He entered the steel industry at Bairds & Scottish Steel, working there from 1932 to 1938, and in 1938 he joined Colvilles Ltd. In 1947 he joined Algoma Steel Corp., Ltd., as assistant mechanical superintendent; in 1949 he became assistant to works manager, in 1950 was named superintendent of construction, and in 1952 he was promoted to division superintendent maintenance and services. In 1957, he was made manager of engineering and construction, his present position.

JACKSON S. MOORE attended the University of Utah in Salt Lake City, majoring in mechanical engineering. He moved to the Los Angeles area, joining the Columbia-Geneva Steel Div., United States Steel Corp., Torrance Works, in 1936, as third helper in the open hearth department. Subsequently he has held positions as industrial engineer, maintenance engineer, assistant superintendent of maintenance, superintendent of maintenance and utilities and assistant superintendent of rolling mills, the position he now holds.

H. W. DORSET was graduated from Clemson College, South Carolina, receiving a bachelor of science degree in electrical engineering in 1930. He joined the Westinghouse Electric Corp. in Pittsburgh on the test course and was transferred to the Baltimore office in 1932. In 1933 he entered the employ of the Bethlehem Steel Co., Sparrows Point plant in the 110-in. plate mill, and in 1935 was transferred to the electrical department construction division. Mr. Dorset has served as construction foreman and assistant electrical engineer. In 1952 he became assistant electrical superintendent, which position he now holds.

JAMES H. FRANZ was born in Glenshaw, Pa. After completing high school at Etna, he started work with Carnegie Steel Co. as an electrician's helper. From 1929 to 1941 he held various jobs in the maintenance and engineering departments. Meanwhile, he attended Carnegie Institute of Technology night school, receiving a bachelor of science degree in electrical engineering in 1941. He was made chief electrical engineer of Carnegie-Illinois Steel Corp. ordnance engineering bureau and in 1943 was transferred to the company's Youngstown district. In 1946 he was named assistant to the division superintendent of maintenance of the Youngstown district and in 1948 became superintendent of operating maintenance. He was then made supperintendent of the fabricating shops at the McDonald mills. In 1951 he was transferred to U. S. Steel's Edgar Thomson works as superintendent of operating maintenance, his present position.

B. W. HYDE was born in Hannibal, Mo., in 1912. He was educated in the public schools in that city and was graduated from the University of Missouri in 1933, receiving a bachelor of science degree in engineering. For eight years he was employed in highway and building construction. He spent three and one-half years in the Corps of Engineers during World War II with two years in the CBI theatre on the Ledo and Burma roads. He attained the rank of Major. In 1946 he joined the Laclede Steel Co. as construction engineer, and was made superintendent of service and maintenance in 1955 which position he still holds.

W. L. MURPHY attended the California Institute of Technology under the Naval V-12 College Training Program graduating in 1945 with a bachelor of science degree in mechanical engineering. In 1947 he received a master of science degree in production engineering from Stanford Unversity. He entered the employ of the Bethlehem Steel Co. in 1947 as a member of the loop course training program. He was subsequently assigned to the South San Francisco plant, progressing through the following positions: draftsman fuel engineer, assistant superintendent open hearth department, and assistant to the general manager. In 1958 he was appointed to his present position of assistant general manager of the South San Francisco plant.

GEORGE KOSS is a native of Gary, Ind., and attended school in that city. In 1935 he joined the Gary Works, United States Steel Corp., as a laborer. In 1938 he was transferred to the Irvin Works, holding various positions in the sheet and tin mill. In 1948 he returned to Gary as general foreman, cold-reduction mill. In 1950, Mr Koss was named superintendent of the cold reduction mill at the Pittsburg, Calif., works, and in 1952 was made superintendent—slab, plate and strip mills as the Geneva Works. In August, 1956, he was promoted to his present position as assistant division superintendent rolling mills, Geneva Works.

FRED M. FARRAGHER was born in Youngstown, Ohio. In 1930 he joined the United States Steel Corp., starting in the boiler shop, then working in the various Youngstown district plants—the lower mills, upper mills and the McDonald plant, and transferring to the machine shop at McDonald. In 1948, Mr. Farragher became assistant general foreman of blast furnace maintenance, in 1951 he was made general foreman, and in 1952 was named superintendent. On January 1, 1958, he was promoted to his present position as superintendent blast furnace auxiliaries.

JOHN R. HUNT
Birmingham District Section

R. D. HINDSON
Buffalo District Section

ROBERT J. GARMY
Canton District Section

Elmer O. KRUEGER
Chicago District Section

WILLIAM P. SMITH
Cleveland District Section

HAROLD V. GUMMA
Colorado District Section

J. L. LAIDLAW
Detroit District Section

JACKSON S. MOORE
Los Angeles District Section

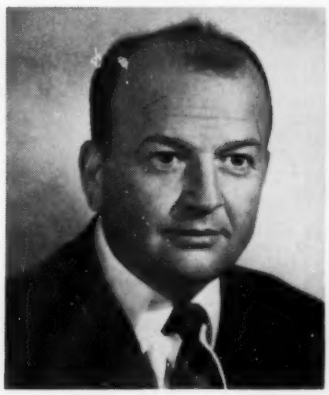
H. W. DORSET
Philadelphia District Section

JAMES H. FRANZ
Pittsburgh District Section

B. W. HYDE
St. Louis District Section

W. L. MURPHY
San Francisco District Section

GEORGE S. KOSS
Utah District Section



FRED M. FARRAGHER
Youngstown District Section

PROGRAM

AISE SPRING CONFERENCE

Auspices of Rolling Mill Committee

SHERATON HOTEL
PHILADELPHIA, PA.

April 25, 26, 27, 1960

MONDAY, APRIL 25

8:30 am—REGISTRATION—
Parlors C–D

9:00 am—ELECTRICAL SESSION—
Independence and Constitution Rooms

Chairmen: R. G. Nolan, Electrical Engineer, Granite City Steel Co., Granite City, Ill.

H. W. Dorset, Assistant Electrical Superintendent, Bethlehem Steel Co., Sparrows Point, Md.

"Hot Strip Mill Electrical Systems—Design Trends," by W. M. Krummel, Steel Mill Application Engineer, Metal Rolling and Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

"Automatic Gage Control on Reversing Cold Strip Mills," by Alonzo F. Kenyon, Advisory Engineer, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

"A Program for Automation of High Speed Temper Mills," by D. E. Rea, Application Engineer, Industrial Systems Dept., and R. C. Lopez, Control Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

9:00 am—ROLLING MILL SESSION—
Pennsylvania Room

Chairmen: F. G. Kredel, Chairman of Bar Mill Committee, Republic Steel Corp., Cleveland, Ohio

H. S. Millington, Mill Engineer, Bethlehem Steel Co., Bethlehem, Pa.

"Retaining Flexibility in the Design of Mechanized Merchant Bar Mills," by Edward C. Peterson, Vice President, Rolling Mill Equipment Div., and William H. Boblitz, Roll & Mill Machinery Sales Engineer, Birdsboro Corp., Birdsboro, Pa.

"The Operation of a Three-Strand High Speed Rod and Merchant Mill," by A. H. Griffiths, Superintendent of Rolling Mills, Sheffield Div., Armco Steel Corp., Kansas City, Mo.

"Investigation of Spalling of Work and Back-Up Rolls in Hot and Cold Strip Mills," by James V. Latorre, Research Engineer, and M. K. Chakko, Metallurgical Research Laboratory, Syracuse University Research Institute, Syracuse, N. Y.

2:00 pm—ROLLING MILL SESSION—
Pennsylvania Room

Chairmen: Howard S. Orr, Project Development Engineer, United States Steel Corp., Pittsburgh, Pa.

R. C. Schaefer, Assistant Superintendent, Hot Strip, Soaking Pit, and Blooming Mill Dept., Wheeling Steel Corp., Steubenville, Ohio

"Roll Wear in Finishing Trains of Hot Strip Mills," by Dr. George Sachs, Associate Director, James V. Latorre, Research Engineer, and M. K. Chakko, Metallurgical Research Laboratory, Syracuse University Research Institute, Syracuse, N. Y.

"Instrumentation for Hot Strip Mill Test Program," by N. S. Wells, Section Head-Application, Special Controls and Drives, Electrical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

"Analysis of Operational Factors Resulting From Hot Strip Mill Tests," by John S. Ride, Metallurgist, Development and Special Duties Div., Metallurgical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

2:00 pm—COMBUSTION SESSION—
Independence and Constitution Rooms

Chairmen: William M. Bloom, Senior Fuel Engineer, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

E. W. Fitch, Chief Combustion Engineer, Republic Steel Corp., Youngstown, Ohio

"Profit Improvement Through Waste Fuel Utilization," by R. E. Leip, Utilities Coordinator, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Investigations into Transient Temperature Distributions Within Slabs Heated in Continuous Furnaces," by A. H. El-Waziri, Senior Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

"European Experience with the Electrically Heated Soaking Pit," by Harald C. Bjerke, Special Engineer, Rust Furnace Co., Pittsburgh, Pa.

TUESDAY, APRIL 26

9:00 am—MECHANICAL SESSION—
Independence and Constitution Rooms

Chairmen: G. M. Kyle, Assistant Mechanical Superintendent, Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

Charles H. Good, Jr., Chief Engineer, Central Operations, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

"Ductile Iron in Steel Mills—Its Properties, Applications and Usefulness in Operations and Maintenance," by Charles R. Isleib, Metallurgist, Ductile Iron Div., The International Nickel Co., Inc., New York, N. Y.

"Some Concepts of Mill Bearing Lubrication Employing Oil, Plastic Grease and Oil Mist," by O. G. McCandless, Lubrication Advisor, Butler Plants, Armco Steel Corp., Butler, Pa.

"Trends in Rolling Mill Drive Design," by Roger Jones, Sales Manager—Metal Producing Industries, Industrial Products Div., Western Gear Corp., Belmont, Calif., and Royal Hawley, General Supervisor, Design Engineering, Seattle Works, Western Gear Corp., Seattle, Wash.

9:00 am—ROLLING MILL SESSION—
Pennsylvania Room

Chairmen: J. L. Dawson, Superintendent, Blooming, Hot Strip & Rolling Mills, Jones & Laughlin Steel Corp., Aliquippa, Pa.

W. E. Dittrich, Superintendent, No. 2 Mills Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

"An Analysis of the Stresses and Deformations in Work Rolls," by Carl F. Zorowski, Assistant Professor of Mechanical Engineering, and Alvin S. Weinstein, Assistant Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

"Soaking Pit Expansion and Installation of Slabbing Mill at Kaiser Steel's Fontana Plant," by M. L. Gruver, Superintendent, Blooming, Slabbing and Structural Mills, Fontana Works, Kaiser Steel Corp., Fontana, Calif.

"46-In. Blooming and Plate Mill," by J. L. Laidlaw, Manager of Engineering and Construction, and J. H. Walshaw, Superintendent, 46-In. Blooming and Plate Mill, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

2:00 pm—OFF-THE-RECORD ROLLING MILL PANEL DISCUSSION—

FIRE-CRACKING IN ROLLS SESSION—Combined Meeting with Roll Manufacturers Institute—
Pennsylvania Room

Moderator: John Dugan, Vice-President—Operations, The Ohio Steel Foundry Co., Lima, Ohio

RMI Panel: W. D. Hacker, Superintendent, Foundry Operations, Mesta Machine Co., West Homestead, Pa.; J. W. Luoma, Technical Assistant, Roll Sales Dept., Blaw-Knox Co., East Chicago, Ind.; E. P. Sandbach, Chief Metallurgist, Mackintosh-Hemphill Div., E. W. Bliss Co., Pittsburgh, Pa.

AISE Panel: E. M. Benedict, Superintendent—Roll Shop, South Works, United States Steel Corp., Chicago, Ill.; James N. Imel, Superintendent, Sheet & Tin Strip Depts., Pittsburgh Works, Jones & Laughlin Steel Corp., Pittsburgh, Pa.; Louis Moses, Bethlehem, Pa.; H. E. Muller, Superintendent Roll Dept., Indiana Harbor Works, Inland Steel Co., East Chicago, Ind.

7:00 pm—INFORMAL STAG DINNER—
Grand Ballroom

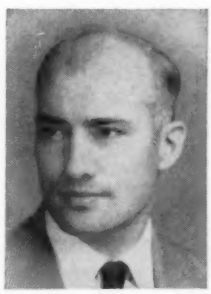
Speaker: Harleson R. Wood, President, Alan Wood Steel Co., Conshohocken, Pa.

WEDNESDAY, APRIL 27

8:25 am—INSPECTION TRIP—

Bethlehem Steel Co., Bethlehem, Pa. Special train leaves from Reading Railroad Terminal at 12th & Market St., in downtown Philadelphia. All attending trip will assemble at Reading Terminal. Allow at least 20 minutes to walk to station from Sheraton Hotel. Train will leave Bethlehem at 2:00 pm and arrive in Philadelphia at 3:20 pm. Box lunches will be served on return train trip, courtesy of Bethlehem Steel Co.

Spring Conference Chairmen



R. G. NOLAN

H. W. DORSET

F. G. KREDEL

H. S. MILLINGTON

H. S. ORR

R. C. SCHAEFER

W. M. BLOOM

E. W. FITCH

G. M. KYLE

C. H. GOOD, JR.

J. L. DAWSON

W. E. DITTRICH

JOHN DUGAN

Abstracts of Technical Papers

to be presented at technical sessions of

AISE SPRING CONFERENCE

April 25, 26, 27, 1960

Sheraton Hotel

Philadelphia, Pa.

"HOT STRIP MILL ELECTRICAL SYSTEMS—DESIGN TRENDS"

by W. M. KRUMMEL, Steel Mill Application Engineer, Metal Rolling & Processing Engineering, Industrial Engineering Section, General Electric Co., Schenectady, N. Y.

W. M. KRUMMEL

△THE recent spurt in hot strip mill construction has stimulated many innovations in the design of the electrical system and accelerated the development of equipment that will make possible more efficient operation with higher quality output than heretofore.

This paper presents many of the design trends that are being incorporated into new hot mills and revamps of existing installations, scheduled to be in operation in 1960.

Of great interest is automatic gage control. The basic gagemeter system which is being used with most of the new equipment is briefly reviewed. There are several ways that the basic gagemeter system is being applied to obtain the results most suited to a particular mill's requirements. In addition, the latest developments in the application and design of electrohydraulic systems, loopers and interstand and delivery x-ray gages are being incorporated into the automatic gage control system. These developments and applications are presented along with important results of analog computer studies on complete mill systems including automatic gage control, loopers and main drives.

Basic to the majority of recent hot strip mills is a stand drive electrical system including individual rectifier power supply and speed regulator control. Fast response and highly accurate rectifier firing controls and speed regulators are being built utilizing the latest component developments in silicon controlled rectifiers, transistors and servo systems. Additional control functions are being added to provide rectifier power supplies with characteristics usually considered unique with motor generator sets. Even so, a comparison of the relative advantages and disadvantages of the rectifier compared with the motor-generator set particularly with respect to effects on the power system and the flexibility for rolling wide ranges of product and product composition should still be made.

With each new installation, management strives to include equipment that will enable closer control over mill operations and output. The integrated data logging system is proposed as a means to provide factual and accurate data on mill production. The finishing train control computer is proposed as enabling more uniform and higher quality mill output. This paper describes the application of computer type equipment which only a short while ago was viewed as being too exotic for the mill operating department, and which is now being considered for installation on new hot strip mills.

"A PROGRAM FOR AUTOMATION OF HIGH SPEED TEMPER MILLS"

by D. E. REA, Application Engineer, Industrial Systems Dept., and R. C. LOPEZ, Control Engineer, Control Dept., Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

D. E. REA

Δ VARIOUS degrees of automatic operation of rolling mills have been successfully put into operation in the steel industry during recent years. An examination of these installations provides an indication as to what type of rolling mill one should consider for future application of automatic operation. Practically all of the installations have been made on rolling mills where continuity of product range (and the smaller the variance in range the better), high mill operating speeds, and repetitive sequence of operating conditions are the criterion of these mills.

Possibly, no other type rolling operation fits more perfectly into these specifications than the two stand temper mill used for producing tinplate gages. Yet, to the authors knowledge, no real effort has been made in the application of recently developed tools of control for this purpose to date.

R. C. LOPEZ

The paper discusses the problems one would expect in such an application, to what extent automatic control can be accomplished at present, in the future and a suggested approach.

At present, temper rolling of tinplate gages would appear to be more of an art rather than a science under manual control of the operator. To relieve the operator of a portion of these functions would be the first step in obtaining a completely automatic temper mill.

The desired qualities of the finished product from the temper mill are known. To determine what extent the various factors involved in the rolling process influence the finished product becomes the prime consideration. The ability of present measuring instruments to detect the variables, and the necessary related equipment to control the variables would be the next phase of investigation. The degree to which this could be applied to high speed temper mill operation would depend on other factors beside the control of the electrical equipment. However, it is felt that obtaining optimum performance of the electrical equipment through some degree of automatic operation would do much to obtain a more uniform quality product.

Tension control between stands through the use of a controlling tensiometer is almost universally applied to present high-speed temper mills and could be called the first step in automatic control. Consideration must be given to this, as well as tension throughout the mill, and the effect it has in determining the quality of the final product. In addition, screwdown pressure and strip extension all play important parts in obtaining uniform hardness, finish and shape. Recent developments indicate these functions could be controlled also. The extent that automatic control can be applied depends primarily on the ability of instruments to determine these quantities on the fly, or knowledge of the incoming coil which would allow manual presetting of the extension, tension and screw pressure to be maintained.

A method of approach and components now available for obtaining some degree of automation is presented in the paper. In addition, a future program for obtaining more complete control of product quality is outlined.

"AUTOMATIC GAGE CONTROL ON REVERSING COLD STRIP MILLS"

by ALONZO F. KENYON, Advisory Engineer, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

A. F. KENYON

Δ THE successful operation and satisfactory performance of an automatic gage control system on any hot or cold rolling mill require detailed engineering analysis and careful co-ordination of the gage regulator with the mill screwdowns, tension regulators and mill and reel main drives.

The paper describes the automatic gage control systems installed on two different single stand reversing cold reduction strip mills recently put into operation, points out the problems involved in the applications, and shows the results which have been obtained during operation.

The first mill is a 16 & 49 x 42-in. single stand reversing cold reduction strip mill, operating at speeds up to about 2060 fpm maximum, and intended primarily to produce light gage grain-oriented silicon electrical steel strip. This mill has a 5500-hp mill drive and two 1400-hp reel drives. The screwdown has two 50-hp motors, with constant voltage magnetic control. The automatic gage control, operating from the delivery side x-ray thickness deviation gage, is arranged to control gage by controlling the: (1) entry tension, (2) screwdown or (3) both entry tension and screwdown. Operating experience has shown that the delivered gage can be satisfactorily regulated by controlling the screwdown alone, however controlling both the strip tension and the screwdown achieves slightly better gage uniformity and reduces the number of screwdown operations by more than three-fourths.

Another mill just beginning regular rolling operation is a 19 & 51 x 56-in. single stand reversing mill, operating up to 1800 fpm maximum, and intended to produce some stainless steel and other hard alloy as well as low carbon steel strip. The main mill drive is 3000 hp, and each reel drive is 1250 hp. The screwdown has two 75-hp mill motors, operating up to double voltage, with variable voltage control from two 75-kw generators. The automatic gage control is generally similar to that for the 42-in. mill, except with static control and regulating devices for the variable voltage screwdown. Because of the relatively long transport time between the mill roll bite and the strip thickness gages when operating

at moderate speed, a quick response integrating sampling system is used both for the screwdown and the tension controls.

"THE OPERATION OF A THREE-STRAND HIGH SPEED ROD AND MERCHANT MILL"

by A. H. GRIFFITHS, Superintendent of Rolling Mills, Sheffield Div., Armco Steel Corp., Kansas City, Mo.

A. H. GRIFFITHS

△ IN 1953 the first thought was given to acquiring more rod mill capacity at the Kansas City plant. At that time, the revamping of the existing No. 1 rod mill was considered. The final unanimous thinking was to build a new installation on adequate grounds. Actual erection of the mill started on November 1, 1957. One thousand load bearing piling 74 ft long were driven and 14,000 cu yd of concrete were poured in the construction of this two story mill. It was determined that the most economical type of structure was obtained by locating the mill floor 14 ft above ground level. Minimum excavations, gravity sewers and accessible piping are a few of the features of this type of construction. Some 100,000 sq ft of the building is under roof.

The selection of a crew was one of the first problems faced by the production department. An agreement between the company and the union for the original staffing of the No. 2 rod mill was signed before the start-up. This agreement basically attested the fact that the men would be drawn from the No. 1 rod mill and the 10-in. merchant mill. It was only necessary to select 27 bargaining unit personnel to fill the first mill operating crew, however 100 people in the seniority group were indivudally contacted and the contrast conditions explained to them.

One turn operation of the mill commenced on June 10, 1959, and eight tons of salable No. 5 rod were produced on this date.

The mill proper is comprised of 23 closed top roll housings equipped with oil-flooded sleeve bearings. Three repeaters are located between stands No. 13 and 14, 15 and 16, and 17 and 18. Round sections are used on all three repeaters for finished rod sizes under $^{13}/_{32}$ in. No. 5 rod to $^{11}/_{16}$ in. is produced from a $2^{3}/_{4}$-in. billet, 40 ft long, weighing 1000 lb. Rounds $^{11}/_{16}$ through $1^{3}/_{8}$ in. will be rolled from $3^{5}/_{8}$-in. billets producing bundle weights of 1760 lb.

Billets are unscrambled automatically and fed into a two-zone, 112-ton per hr furnace. This side-charged, side-discharged furnace has hearth dimensions of 43 x 50 ft. Gas or oil may be used in the operation of the furnace with the oil being the standby fuel.

Primary a-c power for the mill is converted to direct current by the use of rectifiers. Stands No. 1 and 2 are driven off one gear reducer as are stands No. 14 and 15 and No. 16 and 17. Individual drives are used on stands No. 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 and 13. The six-stand finishing train is driven from both ends with 1250-hp motors. The total horsepower available on the mill is 11,500.

Roller twist delivery guides are used throughout the roughing and intermediate mills. In the finish train, high-speed roller twist units of the latest design are working very satsifactory at 6000-fpm delivery speeds. No trouble is anticipated for maximum operating speeds of 6500 fpm.

Six air-cooled laying reels produce a bundle of No. 5 rod 34 x 46 x 14 in. high weighing 1000 lb. Delay stations following the reels allow the mill to be emptied without loss of steel when trouble develops on the conveyor or hook carrier.

Air and water cooling of the rod has dropped the temperature of the finished coil to 1000 F with 0.5 per cent scale on low carbon rods.

"RETAINING FLEXIBILITY IN THE DESIGN OF MECHANIZED MERCHANT BAR MILLS"

by EDWARD C. PETERSON, Vice President, Rolling Mill Equipment Div., and WILLIAM H. BOBLITZ, Roll & Mill Machinery Sales Engineer, Birdsboro Corp., Birdsboro, Pa.

E. C. PETERSON

△ FLEXIBILITY in mechanized bar mills is affected by: (1) mill layout, (2) design of individual items of equipment and (3) roll pass design and arrangement.

Some mill layouts lend themselves to considerable flexibility, but the production is low and the labor cost is high. Other layouts eliminate manual labor entirely and lend themselves to high tonnage rates, but flexibility is adversely affected. Compromise layouts which lend themselves to mechanization and high tonnage without unduly impairing flexibility are possible. These layouts must be tailored to individual conditions, and numerous features should be considered when planning a new mill which has to do jobbing work.

W. H. BOBLITZ

In designing individual items of equipment for these mills, the items should be as universal as possible so that they can handle a maximum number of sections without any change of parts. Mechanical adjustments which are necessary should be simple to make. When items of equipment must be changed, they should be arranged so they can be left in the mill in an inoperative position, if possible.

Some systems of roll pass design permit variations in stock, affording changes in finished size with a minimum of groove changes. Such systems of reduction lend themselves to bar mill flexibility.

The arrangement of the various passes in the mill rolls must be studied carefully, to permit the production of the mill's complete range of sizes and sections with a minimum of roll and guide changing.

"INVESTIGATION OF SPALLING OF WORK AND BACKUP ROLLS IN HOT AND COLD STRIP MILLS"

by JAMES V. LATORRE, Research Engineer, and M. K. CHAKKO, Metallurgical Research Laboratory, Syracuse University Research Institute, Syracuse, N. Y.

J. V. LATORRE

△ THIS paper presents the procedures used by the Metallurgical Research Laboratory of Syracuse University Research Institute and the data collected in the investigation of spalling of work and backup rolls in the finishing trains of three hot mills and one tandem cold mill. The program is sponsored by the Joint Roll Research Committee of the Association of Iron and Steel Engineers and the Roll Manufacturers Institute of Pittsburgh, Pa.

During the investigation period, which covered the two years of 1958 and 1959, considerable data were collected on the relation between measurable variables of hot and cold strip mill operation and the geometrical characteristics of the work and backup roll wear patterns. This included observing and measuring or recording the mill power, roll separating forces, roll and strip speeds, reduction, slip between work and backup rolls, strip rolling schedules, hot and cold roll contours, roll surface temperatures after rolling and other operating characteristics.

M. K. CHAKKO

The evaluation of these data permitted development of methods of measuring and comparing the wear of rolls as a function of strip tonnage and strip mileage and the influences of stand position and roll separating forces on this wear. The detailed evaluation of the mechanism of roll wear is covered by another paper. These data also permit an appraisal of the average temperatures developed in the roll during rolling and the resulting "puffing" of roll contours.

It was found that roll surface temperature in general followed a parabolic distribution for all mills and that the average temperature from core to surface may be higher than the surface temperature for hot mill work rolls and approximately the same as the surface temperature for cold mill work rolls. Hot mill backup rolls remain at fairly uniform temperatures, about 10 to 20 F above the cooling water temperature. Cold mill backup rolls were not checked except when cold.

Observation in the mills also permitted the taking of photographs of the types of roll surface defects developed during rolling and their probable relation to spalling and the breakdown of roll surfaces. These photographs suggest a relationship between fire cracking and skin spalls as well as some of the wear pattern irregularities observed.

Roll separating forces were determined from strain gages mounted on mill housings of the 56-in. mill. Data obtained were inadequate for calculation of loads from mill power data, but the strain gage data indicated loads between the work and backup rolls of about 60,000 lb per in. of contact length with maximum recorded loads of 100,000 lb per in. of roll length, assuming a uniform distribution of load. Worn roll contours are expected to cause maximum loads considerably higher.

Observations also pointed out the deficiences of the roll record cards of many mills and the limited value they contribute to an accurate analysis of the loss of roll life due to spalling. A revised system of keeping roll records is suggested for further development by AISE as a standard in the steel industry which will give a better accounting of the loss of roll life due to spalls than is presently possible.

"ROLL WEAR IN FINISHING TRAINS OF HOT STRIP MILLS"

by DR. GEORGE SACHS, Associate Director, JAMES V. LATORRE, Research Engineer, and M. K. CHAKKO, Metallurgical Research Laboratory, Syracuse University Research Institute, Syracuse, N. Y.

DR. GEORGE SACHS

△ THE paper presents the results of a program sponsored by the Joint Roll Research Committee relating to roll wear in three 6-stand hot finishing trains of different widths and one cold tandem mill of steel strip rolling mills.

Regarding the wear of the work rolls of hot finishing trains, it was observed that the wear patterns in all except the first two stands were clear images of the rolling schedule. A schedule which comprises rolling a large variety of strip widths usually results in a depression of the form of a box with walls sloping between the extreme edge positions of the various strip widths. Any increased rolling of strip of a given width develops a step in this wear pattern. The bottom of this box appeared to be nearly straight or slightly concave in the narrow and intermediate mills. In contrast, the bottom of the wear pattern was distinctly convex in the wide mill. This indicates considerable bending of these rolls during rolling. The frequency of irregularities in the wear patterns decreases from the first to the last stand. Usually quite symmetrical wear patterns are observed in stands No. 5 and No. 6, and frequently rather irregular patterns in stands No. 1 and No. 2. The wear patterns in stands No. 1 and No. 2 vary widely from mill to mill. Excessive wear near the edges of the wear pattern appeared to be associated with "skin spalling." The magnitude of wear for a given mileage generally decreased progressively from stand No. 3 to stand No. 6. The amount of wear in stands No. 1 and No. 2 varied greatly from mill to mill. A difference in the magnitude of wear for cast steel and cast iron work rolls respectively could not be definitely established.

In the wear of the backup rolls of hot finishing stands, it was observed that wear occurred over the entire length of the rolls. The wear was usually greater in the center than at the edges, with some indication

of a depression similar to that of the respective work roll, but with the maximum wear at the roll center generally less than twice the wear at the roll edges. The magnitude of wear for a given mileage decreased progressively from stand No. 3 to stand No. 6. The amount of wear in stands No. 1 and No. 2 varied greatly from mill to mill, with either maximum or minimum wear for a given mileage occurring in stand No. 2. The rate of wear of backup rolls was only a fraction of that of the respective work roll.

The normal wear of either the work rolls or the backup rolls of a 56-in. cold strip 5-stand tandem mill has been found to be nearly insignificant, except for stand No. 1.

"INSTRUMENTATION FOR HOT STRIP MILL TEST PROGRAM"

by N. S. WELLS, Section Head—Application, Special Controls and Drives, Electrical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

N. S. WELLS

△ THE Steel Co. of Canada actively participated in the series of hot strip mill investigations initiated by the Joint Roll Research Committee under its roll spalling and wear program. In addition to the work involved in this project, The Steel Co. of Canada also carried out a parallel project to obtain additional information on significant mill rolling parameters to supplement extensive studies previously made on this mill.

The major test requirement was for the accurate measurement of stand roll separating force on two selected stands. In actual fact roll force measuring devices were installed on all stands. Load cells could not be economically justified for what was basically a short term test program. Therefore relatively simple bolted roll force measuring devices were used. These consisted of strain multiplying bars using resistance strain gages as the sensing element. A 2500-ton hydraulic jack inserted between the stand backup rolls was used to calibrate each unit in position on the housing. Figures of all interstand strip gages and speeds for various schedules were obtained indirectly by using a cascaded arrangement of the roll force signals to produce precise strip interval times between successive mills.

Various methods of measuring the work roll surface temperature during rolling were also investigated. The final system used for these tests employed brush thermocouples previously developed by the research department of the Bethlehem Steel Co. Temperature measurements were made at three and five points along the length of the work rolls on two stands and indicated and recorded successively on a single chart recorder.

An attempt was also made to prove or disprove the existence of slip between mating work and backup rolls in a single stand. In this case digital counting techniques were employed utilizing pulse generators on the rolls.

In addition to these specialized measurements further standard instrumentation in the form of multi-channel recording oscilloscopes was used extensively to monitor individual motor electrical loads and speeds.

"ANALYSIS OF OPERATIONAL FACTORS RESULTING FROM HOT STRIP MILL TESTS"

by JOHN S. RIDE, Metallurgist, Development and Special Duties Div., Metallurgical Dept., The Steel Co. of Canada, Ltd., Hamilton, Ontario, Canada

J. S. RIDE

△ IN May, 1959, Syracuse University Research Institute, under contract to the Joint Roll Research Committee, carried out a comprehensive test program on the 56-in. hot strip mill at Hamilton Works of The Steel Co. of Canada, Ltd. In conjunction with this program, The Steel Co. of Canada, Ltd., collected additional data to supplement previous studies made on this mill.

An attempt has been made to determine the actual reductions taken in each stand of the finishing train by the use of a cascaded strain gage technique. Precise interstand interval times have been determined, allowing the calculation of interstand speeds and interstand thicknesses for approximately 450 coils.

Measurements taken for the determination of actual drafts are used to try and establish a relationship between per cent forward slip on each stand and the per cent reduction taken on that stand.

The effects of various rolling parameters on the roll separating force obtained on each stand are investigated. Equations are derived, using computer techniques, to relate these parameters to the roll separating force.

An attempt is made to relate the roll separating force as measured by the strain gages to the electrical load measured by recording oscilloscope.

A nomogram is developed relating the slab dimensions to rolling time on the reversing rougher, entry temperature to the continuous finishing train and head and tail and finishing temperatures off the finishing train. This allows the estimation of the performance of the mill for varying production schedules.

"PROFIT IMPROVEMENT THROUGH WASTE FUEL UTILIZATION"

by R. E. LEIP, Utilities Coordinator, Fairless Works, United States Steel Corp., Fairless Hills, Pa.

R. E. LEIP

▲ THE paper shows the advantages of utilizing waste fuels to the fullest before using purchased fuel. The method shown to accomplish this is by scheduling the mills to consume the available waste fuels with the best possible operating turn coverage.

Btu's were selected as the common denominator and both fuel and power available to the plant were converted to these

units. To pinpoint the areas where the most savings and utilization of Btu's could best be accomplished, a chart was made showing the Btu's available plus the consumption of the base operating units of the plant. These so-called base operating units are units requiring a twenty-four hour, or around-the-clock, coverage such as the blast furnace, open hearth, coke plant, etc.

Btu consumption of the individual operating mills such as the 45-in. slabbing mill, bloom and billet mills, etc., was calculated and built upon this base operating line according to the turns scheduled. When all of the operating mills had been added, the graph clearly showed the exceptionally low and high consumption turns. The schedule was then changed by moving one or two of the mills to other turns until the desired turn coverage was accomplished. With all the waste fuel turns covered as well as possible, the volume of purchase fuels needed is automatically reduced, and exceptionally high turns lowered within the Btu's available to the plant; thereby bringing about product cost reduction.

"INVESTIGATIONS INTO TRANSIENT TEMPERATURE DISTRIBUTIONS WITHIN SLABS HEATED IN CONTINUOUS FURNACES"

by A. H. EL-WAZIRI, Senior Technologist, Applied Research Laboratory, United States Steel Corp., Monroeville, Pa.

A. H. EL-WAZIRI

△ IN the process of heating slabs in continuous reheat furnaces, a longitudinal temperature variation is produced within the slabs and is attributed to the water-cooled skids that support the slabs in the heating zone of the furnace. This variation, commonly known as "skid marks" is the principal cause of the periodic thickness variation in the hot-rolled strip and of the subsequent periodic gage variation in the finished strip.

The latter is a defect, which, if severe, can result in rejection of the finished product for critical applications. To eliminate the source of this defect, a high degree of temperature uniformity has to be achieved in the heated slabs.

In order to evaluate means for eliminating skid marks, it is essential to establish the manner in which the transient temperature distribution varies within a slab and the dependence of this distribution upon the method of support in the heating zone.

For this purpose, a mathematical model for the process of heating slabs in continuous reheat furnaces has been developed with the postulation of certain realistic assumptions. This model simulates the heating process and deploys the finite-difference method of solving the differential equations of heat transfer with boundary conditions dependent on time. The computations are performed on a high-speed digital electronic computer. The heat diffusion along the furnace length is neglected.

A typical three-zone furnace of conventional construction is chosen as the subject of investigation by the method developed. Results of the investigation are presented in graphical form.

Two methods of minimizing skid effects were evaluated. Computations for a method involving elevation of skid coolant temperature indicate that a rise of coolant mean temperature from 100 to 900 F results in a 40 per cent improvement in the temperature uniformity.

Analysis of the second method, which involves six various alternative skid configurations without changing the presently used skid coolant temperature, reveals that significant improvement in temperature uniformity is possible with this method. This improvement is over 80 per cent for one of the skid configurations investigated.

The method of investigation presented is applicable to various operating conditions; however, the optimum skid configuration has to be ascertained for any specific set of conditions.

It is suggested that the results of this investigation will not only enable improvement of furnace performance but may also make possible an increase in furnace productivity.

"EUROPEAN EXPERIENCE WITH THE ELECTRICALLY HEATED SOAKING PIT"

by HARALD C. BJERKE, Special Engineer, Rust Furnace Co., Pittsburgh, Pa.

H. C. BJERKE

△ EUROPEAN experience with the electrically heated soaking pit dates back to 1927 when the first operating unit was built at Christiania Spigerverk Iron & Steel Works, in Oslo, Norway. Systematic introduction of electric soaking pits to steel mills in other countries was not considered feasible, however, until several years after World War II. At that time it became evident that the inherent advantages of electric heating would in the future be economically justified in most parts of the world due to the favorable trend in cost and availability of electrical energy with respect to other energy forms.

The electric soaking pit has since 1954 found wide acceptance in mills covering the whole range of qualities including carbon, stainless and alloy steels.

Controlled scaling, uniform heating, low standing losses, compactness and simplicity are some of the advantages, but their relative importance will differ from case to case.

In this paper the author intends to describe the electric soaking pit in general, and some of the more typical installations in particular.

There are two main fields of application for the electric soaking pit. Aside from the obvious application to the heating and soaking of special steels, there is also considerable economic advantages to be gained by operating electric pits in connection with the new oxygen steelmaking processes. These processes are

characterized by yielding a relatively small number of hot ingots with short track-time at regular intervals. Energy consumption as low as 15 kwhr per ton as a weekly average is attainable under such circumstances.

An interesting new field is also opened up for application of the same type of heating to forge furnaces of various types, continuous reheating and holding furnaces for rolling and extrusion, and to combined fuel fired and electrically heated furnaces.

"DUCTILE IRON IN STEEL MILLS—ITS PROPERTIES, APPLICATIONS AND USEFULNESS IN OPERATIONS AND MAINTENANCE"

by C. R. ISLEIB, Metallurgist, Ductile Iron Div., The International Nickel Co., Inc., New York, N. Y.

C. R. ISLEIB

Δ MANY mill operators and engineers are realizing outstanding service economies through the use of ductile iron castings. In the ten years since the first commercial heat of ductile iron was poured, worldwide production has grown to about 450,000 tons in 1959, about 20 per cent of this being used by the steel industry.

Ductile irons are generally highly resistant to wear, corrosion and high temperature oxidation. They are strong, tough and have unusually high yield strength. These properties are especially valuable in steel plant applications.

Their excellent castability and machinability are important design considerations.

Ductile iron rolls produced by several of the major roll makers are finding more and wider applications in American mills. Acicular ductile iron work rolls have been produced as hard as 85 sceleroscope. Ductile iron roughing rolls containing one to two per cent nickel are quite widely used.

Unalloyed ductile iron runout table rolls result in a minimum of scratching, as well as being superior in resistance to wear and breakage.

Ductile iron guides, apron plates and side guard inserts resist wear and warpage far more than cast or wrought steel in these applications.

Ductile iron gears, in addition to their high wear resistance, are economical to machine and easy to harden.

In the melt shop ductile iron furnace castings resist warpage and breakage, and in many cases allow weight reductions because of the material's high strength and toughness.

Open hearth charging boxes are one of the well known success stories of ductile iron.

Ductile iron coke oven doors and frames are standard equipment in several plants.

As mill operators become assured of the high quality that can be expected from skilled producers of ductile iron, it is taking its place as the material choice in many applications throughout metal processing plants.

"SOME CONCEPTS OF MILL BEARING LUBRICATION EMPLOYING OIL, PLASTIC, GREASE AND OIL MIST"

by O. G. McCANDLESS, Lubrication Advisor, Butler Plants, Armco Steel Corp., Butler, Pa.

O. G. McCANDLESS

Δ MANY excellent works have been written covering specific facets of the handling and use of mill bearings. It is not the author's intent, therefore, to retread the path of predecessors who have so ably presented so much factual data in this field but to touch more closely on matters pertaining to the lubricants used and their application.

The subject of plain bearings, using oil circulation systems, vs antifriction bearings, using a plastic grease, is highly controversal with mill operating people and particularly so between engineering groups—not to mention the respective manufacturers' of mill equipment.

Hence, as regards the lubricant, some thought might be devoted as to how it gets where it should go, what happens after it reaches its intended destination and perhaps which one should be selected.

Since the "Total Cost" is the final measure of optimum performance of whatever type of bearing, kind of lubricant or method of application—a strong look at the components of "Total Cost" would seem in order.

The types of mills which fall under scrutiny in any such discussion are blooming, 2-high temper pass-sheet, 4-high tandem cold reduction—multiple stands, 4-high tandem hot strip—multiple stand finishing mills—using plain bearings, and their counterpart with antifriction bearings employing plastic lubricants. Also 4-high—single stand reversing—tension mills. Shape rolling mills such as pipe, structural and wheel mills should not be forgotten.

A very basic understanding of all phases involved in the development of a mill to do a specific job must be considered from an engineering, purchasing, construction, maintenance, production and safety standpoint. The reason is "The Total Cost."

Certain standards of yield are to be attained and maintained if reasonable cost of finished product is to be expected.

Too many times we fail through a lack of sensible planning prior to purchasing and construction of equipment. Provisions must be made to operate such equipment with a minimum of maintenance service. Therefore, close scrutiny must be given to safety measures, adequate room and provision of all necessary equipment to best service the equipment both during operations and shutdown periods.

Therefore, we are concerned with every element entering the picture from the selection of location, area required for the operation through size and shape of excavation, provision for drains in locations which will take care of spillage and of leakage in the

underground area as required, and the general arrangement of underground equipment with emphasis on sufficient space.

Where the mill equipment is especially large in physical nature involving several systems of circulating oil, coolant, hydraulics, etc., thought must be given as to how best to deliver the many supplies for initial and make-up oil, filters, coolers, motors, pumps, pressure vessels and the like. Where supply tanks are required—periodic cleaning is a must and provision to economically and effectively do the job be well planned. Bulk fluid oil requirements indicate savings may be substantially made using tank cars or transport delivery with suitable piping arrangements to convenient unloading stations.

Tighter specifications should accompany purchase orders covering oil storage, supply tanks, filters, coolers and allied equipment.

Air-borne oil, as a fine spray, mist or fog, while it is not the answer to all lubrication ills, has proved invaluable in many applications and has moved to a place of prominance—a means of lubricant application. As such, in view of the fact that "mist" is relatively new, it deserves a full analysis as a competitor in this field as to its advantages and limitations.

"TRENDS IN ROLLING MILL DRIVE DESIGN"

by ROGER JONES, Sales Manager—Metal Producing Industries, Industrial Products Div., Western Gear Corp., Belmont, Calif., and ROYAL HAWLEY, General Supervisor, Design Engineering, Seattle Works, Western Gear Corp., Seattle, Wash.

ROGER JONES

ROYAL HAWLEY

△ THE history of the steel industry is highlighted by major advances in metallurgy and rolling techniques. Trends in rolling mill drive design have resulted in higher performance machinery used in rolling operations. As equipment and maintenance costs increase, these drive improvements should be better known to plant engineers.

Cast tooth mill pinion gears are no longer modern equipment, however, many are still in use. Modern mills are driven by roller bearing equipped pinion gears operating in sealed cases. Wobbler ends can be readily replaced rather than the old practice of replacing an entire pinion due to wobbler wear.

Modern mills are often driven by combination speed reducer-pinion stands. Lower first cost and reduced maintenance practice are the result. Less space for installation also is an attractive feature.

Selective speed drives are now being used on many new installations. Where the cost of d-c variable speed motor equipment is beyond capital budget, many times a two or three-speed mill drive speed reducer will give comparable results. It should be considered for all new drives where a stoppage to change mill speeds is practical.

The paper concludes that there is much to be obtained that is modern in construction and efficient in operation from recent trends in rolling mill drive design.

"SOAKING PIT EXPANSION AND INSTALLATION OF SLABBING MILL AT KAISER STEEL'S FONTANA PLANT"

by M. L. GRUVER, Superintendent, Blooming, Slabbing and Structural Mills, Fontana Works, Kaiser Steel Corp., Fontana, Calif.

M. L. GRUVER

△ THE scope of the 1956 expansion program at Kaiser Steel Corp.'s Fontana plant was to erect facilities to substantially increase the steel ingot production and provide additional rolling units to convert this increased tonnage to semi-finished and finished steel products.

One of the major projects involved was the enlargement of the existing twelve batteries of soaking pits consisting of two pits per battery, the construction of five new batteries of two pits per battery, and the erection of a 46 x 90-in. universal slabbing mill.

The soaking pits are housed in one of the first buildings erected when the Fontana plant was built in the early 1940's. The original installation consisted of six batteries of two pits each, and the building was lengthened to accommodate the above mentioned twelve batteries by 1954.

The original twelve pits were utilized to provide heated ingots for direct rolling on a 100-in. plate mill. In 1944 a 36-in. blooming mill was installed to provide slabs for the plate mill and blooms for the new structural and merchant mill installations. In 1946 a 36-in. high-lift blooming mill replaced the original 36-in. bloomer. In 1954 the 36-in. high-lift blooming mill was replaced on the same foundation with a 46-in. high-lift blooming mill due to an increased demand for larger slabs for plate, strip and coil production.

These successive expansions of pit capacity and primary rolling capacity all stemming from the original installation created some interesting engineering and construction problems when the pits were enlarged and expanded along with the installation of the 46 x 90-in. universal slabbing mill in the 1956 expansion program.

In October, 1958, the new facilities were placed in operation and the soaking pits were required to provide ingots for the new 46 x 90-in. universal slabbing mill in addition to the 46-in. high-lift blooming mill. The two mill operation being provided with heated ingots from one soaking pit source created numerous operating problems which had to be solved to obtain efficient production.

This paper contains a description concerning some of

the major engineering and production problems that occurred during the construction period and the start-up period on these units.

"46-IN. BLOOMING AND PLATE MILL"

by J. L. LAIDLAW, Manager of Engineering and Construction, and J. H. WALSHAW, Superintendent, 46-In. Blooming and Plate Mill, Algoma Steel Corp., Ltd., Sault Ste. Marie, Ontario, Canada

J. L. LAIDLAW

△ THE mill started operations on February 23, 1959, and is unique in the fact that it has one stand serving either as a blooming or plate mill, depending on what roll train is in the mill.

As a blooming mill the rolls are 46 in. diam x 114-in. face, and as a plate mill, the work rolls are 38 in. diam x 114-in. face, with 53 x 114-in. backup rolls.

The product range covers:

1. Slabs for plate production.
2. Blooms for rerolling in other mills.
3. Beam blanks for a 30-in. structural mill.
4. Tube rounds from 7 to 10-in. diam.
5. Sheared plate up to 104 in. wide from ¼ to ¾ in. thick.
6. Heavy plate beyond ¾ in. thick for flame cut finishing.

J. H. WALSHAW

The mill is powered by two 4000-hp, d-c motors with a speed range of 40/80 rpm, has a 42-in. edger located about 40 ft ahead of the mill, controlling slab width and edge finish.

Provision is made beyond the mill for the future installation of a large scarfing machine, and beyond this point a large mechanical down-cut shear is installed capable of cutting 650 sq in. at 1800 F.

A roller leveler, suitable for plate up to ¾ in. thick, followed by a cooling bed and complete rotary trimming, slitting and cross cut shearing line is in operation.

Two problems on the mill stand design were successfully overcome, the first, a successful dual screwdown drive arrangement for blooming and plate rolling on the same screws, and the second, a specification calling for a maximum of 30-min roll change from ingots to plate. In actual fact changing is now taking between 20 and 25 min, and with further experience and some slight modification to grease and water hose connections, can be further reduced.

"AN ANALYSIS OF THE STRESSES AND DEFORMATIONS IN WORK ROLLS"

by CARL F. ZOROWSKI, Assistant Professor of Mechanical Engineering, and ALVIN S. WEINSTEIN, Assistant Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.

C. F. ZOROWSKI

△ A DESCRIPTION is presented of the analysis of the general problem of stresses and deformations in cylinders subjected to arbitrary normal pressures. The model considered assumes a two-dimensional state of stress analogous to work roll behavior in 4-high or cluster mill strip rolling. General mathematical equations are included which permit the predictions of surface deformations and stress distributions over the entire roll cross section due to any arbitrary normal pressure distribution.

This technique is used to investigate several problems of interest relating to surface deformations and stress distribution. The effect of varying backup loads on the roll surface deformations in the strip contact region is determined. The surface deformations due to a typical friction hill pressure distribution are obtained and compared with Hitchcock's result for the same total load.

A. S. WEINSTEIN

Using this same typical pressure distribution, stress variations in the roll are shown. This state of stress is compared with that predicted assuming an elliptical pressure distribution of the Hertzian type. Three cases are investigated for this elliptical distribution: the same arc of contact, the same total load and the same peak pressure as the typical pressure distribution.

Be Sure To Attend The Inspection Trip!

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Wednesday, April 27

Motor-Braking Methods for Steel Plant Drive Applications

by J. C. PONSTINGL, Engineering Supervisor,
Consulting and Application Dept., Westinghouse Electric Corp., Cleveland, Ohio

A price must be paid for every braking function . . . . mechanical brakes may be least expensive but are not versatile, and friction brakes require maintenance on such parts as shoe linings . . . . highly-controlled internal braking systems may be more expensive, but provide more braking functions . . . . the most economical brake is that which best serves the application.

SUCCESSFUL production drives and metal-working processes in the steel industry of today, require careful and correct selection of braking methods for holding, stopping speed and torque control applications. Production schedules, performance, product quality, and safety depend on it.

Greater productivity at lower cost in the basic industries is being obtained, not only through the use of larger machinery, but also through higher operating speeds, and the interlocking of several production processes. In this latter case, the expression "automation of production" may be appropriate. Tying together processes eliminates "in-between" storage points.

Key requirements in automation are accurate speed control and synchronizing of several systems. Tension control between stands of a mill, accurate slowdown and stopping, positioning of ingot buggies or cranes; all require a form of braking.

In any successful production-process application, the braking functions or requirements must be recognized and a method which can produce these requirements, selected, Figure 1.

A braking function in the most general sense may be defined as the process of developing a retardation torque. This retardation effect may be used one of five ways in a drive.

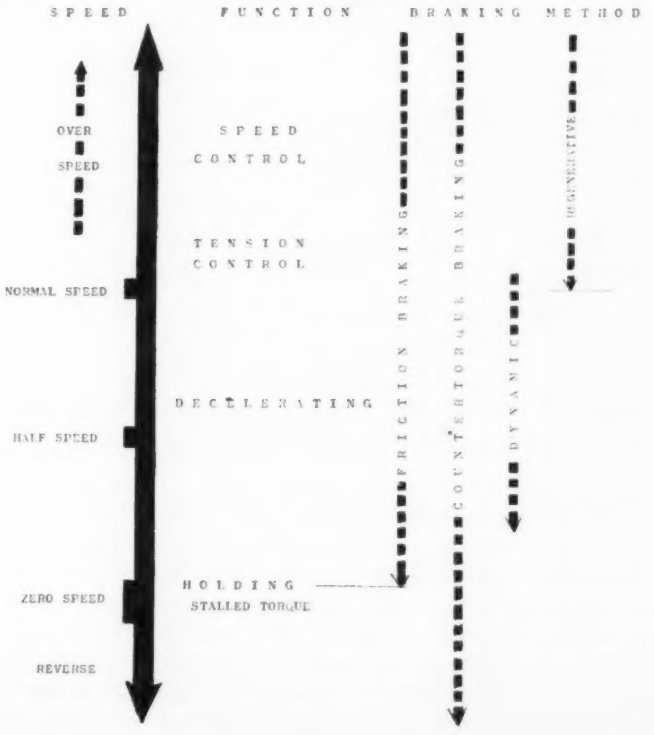
1. Speed control.
2. Torque (or tension) control.
3. Deceleration.
4. Stopping.
5. Holding.

In the first two cases, braking is employed for the purpose of regulating or limiting, either speed and/or torque. For example, when lowering a load with a crane, a retarding action is needed to control or limit increases in speed of the hoist motion for obvious reasons. A braking method is used to produce torque or tension control on metal-working machines ranging from temper-pass mills to slitters.

The functions of deceleration, stopping and holding are perhaps more obvious uses of braking. Without a deceleration-torque, the large flywheel effect prevalent in many machines (ranging from large motor-generator sets to punch presses) would cause rotating members to coast for a long time after the drive motor was de-energized. Often, long stopping-times cannot be tolerated from the standpoint of both production and safety. In the case of screws on a blooming mill, the production rates and automatic operation as from punched-card control demand some type of braking method to stop the motor quickly and hold the screws at a precise point.

Overhauling forces applied to a moving member and the flywheel effect of the member make it necessary for a braking force to maintain or obtain some state of motion.

Figure 1 — Braking methods are used for various functions over a broad speed range, including standstill.



Time required to stop any rotating member in a machine, is directly proportional to the WK^2(moment of inertia or flywheel action) of the member and inversely proportional to the retarding forces including friction and load on the machine. More accurately:

$$t = \frac{WK^2(\Delta N)}{308T}$$

where (ΔN) = speed change in rpm; t = time to produce speed change in seconds; WK^2 = total moment of inertia (in lb-ft^2) as referred to the motor shaft or the point where braking is to be applied; and T = total decelerating torque (in lb-ft). This formula can be used only when torque T (over the speed range) is substantially constant. If this torque varies considerably, calculations should be made in time-increments and the average decelerating-torque during each increment should be used. Increment size depends on the accuracy required, but fair accuracy is obtained if the minimum decelerating torque is not less than 50 per cent of maximum torque in a given increment. Braking-torques versus speed vary considerably for many types of electrical braking methods. Later discussion will bear this out.

It is important to note that the total decelerating torque producing the braking action, includes such factors as frictional forces in the rotating system and existing work loads, in addition to any controlled braking torque that may be applied. Although frictional torques and loads are often overlooked, they may play an important part in the braking cycle. Any overhauling loads in the system will counteract the braking effort and must also be taken into consideration.

Often the loading of a system varies with the speed. This applies to certain types of pump and fan applications. At half speed, a fan load (which is tending to decelerate the drive) may be only one-eighth that at full speed. The braking action then must increase as the fan speed drops in order to maintain a constant total deceleration force all the way to standstill.

The necessary braking torque can be calculated from:

$$T_B = T - T_L - T_F + T_H$$

where T_B = braking torque in lb-ft; T_L = load torque in lb-ft; T_F = frictional torque in lb-ft; and T_H = any overhauling torque in lb-ft.

All these torques must be referred to the motor shaft or the point where braking is to be applied. This also applies to the total WK^2 of the system. In many applications, rotating members such as rolls, flywheels, or reels have high values of inertia (WK^2) but are connected to the motor through a gear transmission, and are rotating at different speeds than the motor. The effective value of WK^2 of say a flywheel referred to the motor shaft can be calculated from:

$$WK^2 \text{ (effective at motor)} = \left(\frac{N_f}{N_m}\right)^2 \times WK^2 \text{ (of flywheel)}$$

where N_f = speed of flywheel in rpm and N_m = speed of motor in rpm. Since the ratio of speed is the gear ratio, it follows that the transfer of WK^2 varies as the square of the gear ratio, or the reciprocal of the square of the gear ratio, depending on whether the transfer is made from a high-speed to a low-speed shaft or vice-versa.

Not all braking and timing calculations can be based on a fixed value of WK^2 for the system. On many process lines speed or braking control of the reels must include inertia compensation since the WK^2 varies with the reel size, during the unwind and rewind process. On a process system involving motor drives on high inertia reels as well as on low inertia loads as leveler rolls, the coordination of braking control to cause the entire line to stop in unison becomes involved.

If a weight is moving in a linear direction such as a trolley on a crane, and is to be braked by a motor, the WK^2 produced at the motor shaft is given by:

$$WK^2 = \frac{PS}{(2\pi N_m)^2}$$

where P = weight of trolley in lb; S = trolley speed in fpm; and N_m = motor speed in rpm.

The braking time or cycle is an important design consideration, especially where the braking forces may be quite high but for a short time interval. Although heat dissipation may not be a problem here, special consideration must be given to the effects that these high forces may have on machinery parts as well as driving motor and work load. Heat dissipation may also become a problem especially in a braking application where stalled-tension is being produced between stands.

BRAKING METHODS

Braking methods or systems as associated with electric motor drives fall into two broad categories; external braking and internal braking.

External braking systems are physically coupled to the drive motor or rotating member to produce braking action. Typical examples are friction type brakes, and eddy-current or (hysteresis) brakes.

Internal braking systems produce a braking action electrically, and within the electric drive motor itself. A braking torque is developed between the motor rotor and stator such as by plugging, dynamic braking or regenerative braking.

External braking systems are best suited where:

1. A holding action is needed.
2. In the interest of safety, a stopping or holding force is needed on electric-power failure. (Dynamic electric braking schemes are also available to provide braking action on power failure.)
3. Additional motor heating due to internal braking systems cannot be tolerated.
4. The system is driven by something other than an electric motor (e.g., diesel engine, etc.)

Internal all-electric braking methods are best suited where:

1. The degree of braking action is to be controlled accurately, automatically or remotely.
2. A holding action is not needed.
3. Braking provision or space is not available for coupling a brake device.
4. Extra motor shaft-extensions are not available.
5. Adding WK^2 to the motor is undesirable because of the high cyclic nature of the application.
6. Many similar machines are tied into one power system, and regenerative braking is beneficial

because of power savings, or synchronized stopping is required.

7. Countertorque action is needed to maintain a tension even at standstill such as on a metal-processing machine.

Friction braking for stopping and holding—The most basic method of braking is the application of a mechanical or friction brake. Either brake shoes or brake bands are applied around the periphery of a brake drum or wheel. Brake bands provide more braking pressure than do shoe brakes. Another version of this form of braking is the disk brake.

Brake-lining and drum designs depend on their use. Mechanical load-brakes used on cranes for lowering loads are designed to dissipate the excessive heat developed during a lowering operation. Brakes used for "holding" only are not subject to brake-lining wear and heating as are those used for speed control or deceleration purposes.

In all cases the braking force is applied mechanically either through the use of manually-operated lever mechanism or some type of drive mechanism. Where remote operation is required, air-operated or hydraulic-operated brakes are selected. Both types employ a combination of springs and an appropriate cylinder for the brake-operating force. For "fail-safe" applications, the brake is "spring-set, power-released." Various combinations of cylinders and springs are available for different braking actions.

A typical air-operated brake may employ a 12-in. cylinder whereas a comparable hydraulic-operated brake will employ a 2-in. cylinder. On railway-type equipment such as locomotive cranes (where air compressors may be available for other applications) it may be desirable to use air-operated brakes. Basically air brakes (up to 250 lb) are less expensive; however, where space is a premium, hydraulic brakes may be more desirable. Mechanical, pneumatic and hydraulically-operated brakes usually employ manually-operated controls. The operating pressures and arrangement of power-set vs power-release are usually determined quite easily once the required functions are known. Mechanically-operated brakes are normally the least expensive, however, they are limited in their versatility.

Electrically-operated shoe or disk brakes differ only in that electric solenoids (both a-c and d-c operated) are the motivating force in either applying or removing the braking force. The thrustor-operated brake is a variation and uses a hydraulic cylinder and piston, the pressure for which is supplied by a small vertical motor and centrifugal impeller. The motor, a 3-phase squirrel-cage totally-enclosed induction machine, operates continuously to hold the brake released. The oil for the hydraulic cylinder is a special grade, little affected by extreme changes in temperature. Adjustable time delay is supplied on standard brakes for delaying setting of brake, up to ten sec. The operation of the thrustor, both in releasing and setting the brake, is cushioned so that the stress of sudden starts and stops is not transmitted to the driven machine.

Most standard shoe or disk brakes are electrically released, and spring set, so that the brake will hold in case of an electrical failure or power interruption. There are applications, however, where the brake is required to release on power failure. This would apply in the case of a shoe brake on the rail-clamp motor of an ore bridge. In this application, an electrically-set, spring-released shoe brake is used. The rail-clamp motor releases the clamp by pulling up a weight at the same time as it opens the clamp (Figure 2). The mechanism is such that if power failure occurs, the shoe brake is released permitting the weight to set the rail clamp.

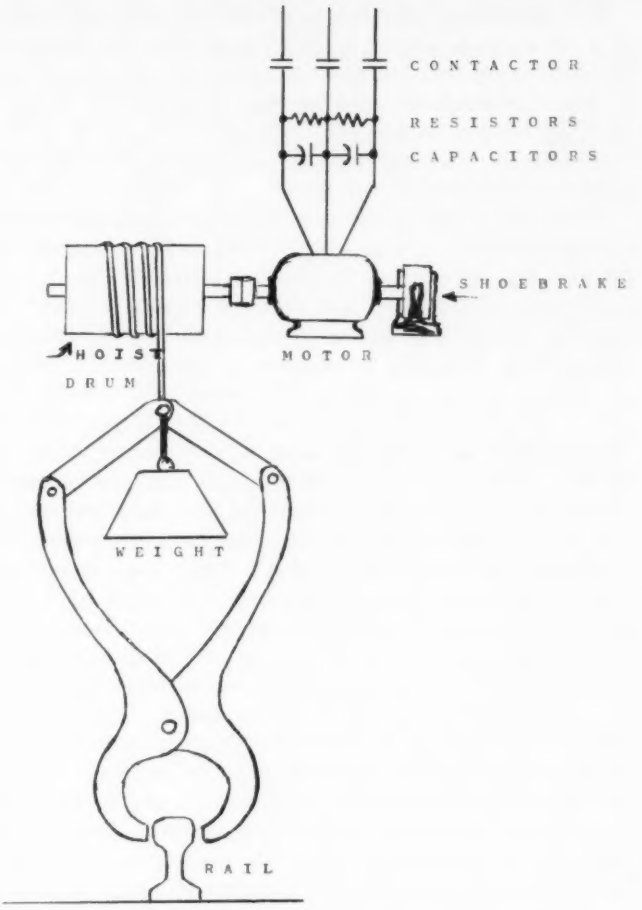


Figure 2 — Simplified schematic of a rail clamp system.

Electrically operated shoe brakes vary, not only in the torque-rating or braking capabilities, but also in the type and voltage rating of the electric magnet or solenoid used to operate the brake. For a-c power sources, a-c operated magnets are available. Because of their laminated structure and high-inrush currents, they are not as suitable for highly-repetitive applications such as on charging machines. Here d-c magnets and rectifiers (to convert the a-c to d-c) are more desirable, because they operate "softer"—not as much hammering.

With d-c power sources, d-c operating magnets are used. Operating coils are not only available for continuous and intermittent duty, but also for overvoltage application. These "overshoot" schemes are used to provide fast action on brake release. Normally d-c magnets with voltage coils operate much slower than a-c magnets, because of the inherent inductance of the coils. Reduced-voltage coils produce high-speed operation when normal voltage is applied. Once the brake is released, however, a resistor must be connected in series with the brake coil to prevent the coil from burning up due to the overvoltage.

A timer or interlock on the brake is used to insert the resistance in series with the brake coil.

The decision of whether to use an intermittent brake or a continuous brake depends on whether the brake is to be released continuously or for intermittent periods such as on the hoist motion of a crane or ore bridge. Holding brakes on process lines may have to be rated continuously because they are energized for the full processing time of a coil.

When shoe brakes are used to provide holding action on applications such as skip hoists, various cranes, or bucket hoists, means should be provided to insure that rated (or nearly rated) hoist motor current is flowing before the brake is released. This prevents momentary dropping or slipping of the load. A series-operating coil using the motor current to release the brake, eliminates this problem. This is applicable on d-c constant potential systems. On adjustable-voltage systems where a shunt brake coil is used, a current-sensitive relay can be connected in the motor armature circuit to detect when it is safe to release the brake.

When applying a brake for holding purposes, it is important to provide sufficient braking torque to do the job. The formula T = HP 5250/rpm—where T = motor full-load torque in lb-ft, HP = motor horsepower rating and rpm = full-load rpm of motor—determines brake torque requirements to match the motor. A brake having the same rating as the driving motor (provided the brake wheel is on the motor shaft) is not always correct. In the case of the trolley motion on a crane, holding-torque may have to be less than 50 per cent. On a bucket drive, the brake on the "hold-line" may have to be twice the motor rating to hold the bucket in the event that the "close-line" brake fails. On high-speed screwdowns, the brake may have to be three or four times the motor rating to prevent movement of the screws when metal hits the mill.

Electrically-operated brakes are normally either "set" or "released" and cannot provide a graduated braking action such as is the case with manually-operated, air-operated or hydraulically-operated friction brakes. As an example hydraulic braking similar to that employed in the automobile, provides a very sensitive braking action. Varying degrees of braking can be employed depending on the pressure exerted by the operator. This makes hydraulic braking desirable on some machines as cranes, man-trolley and bridge motions.

Where excessive operation is encountered, causing considerable wear on the brake linings, some other braking method may be more desirable.

The eddy-current brake produces a dynamic-braking torque by virture of a smooth rotor or drum, rotating in a magnetic field produced by a stationary field coil. Eddy-currents are generated in the surface of the rotor or drum as it rotates. A magnetic attraction between these eddy-currents and the poles of the field-assembly produces a braking torque on the rotor or drum. This torque varies directly with field coil current and with the speed of the rotor or drum and may be infinitely and accurately adjusted by an electronic control system to suit the conditions of operation. Since braking torque is developed by an electromagnetic reaction between separate members, there are no friction members such as disks, bands or linings to wear and require replacement or adjustment. In addition to stopping or deceleration, eddy-current brakes can provide constant tension control such as on unwind stands of metal processing machines.

Speed control with wound-rotor motors is made possible by attaching an eddy-current brake that imposes a load on the motor for operation at reduced speeds. These have application on hoist-drives of small overhead cranes.

Power requirements in the control system of eddy-current brakes are low, especially in relation to the horsepower developed by the units. Eddy-current brakes from 1.5 through 1000 hp are available.

All energy lost in slip between the members of eddy-current equipment is converted to heat. The amount of heat generated is determined by the torque transmitted

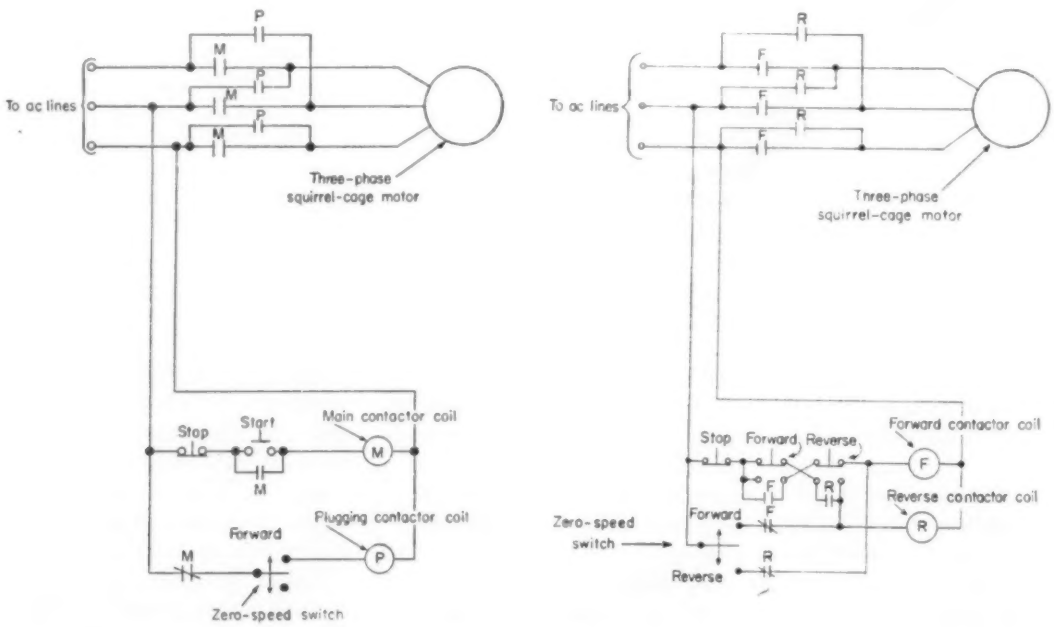


Figure 3 — Typical plugging control circuits for 3-phase squirrel-cage motors.

non-reversing circuit

reversing circuit

through the unit and by the amount of slip between the members. On air-cooled units, vanes on the drum of the unit provide cooling.

Applications involving continued operation at the "high slip-high torque" point or over approximately 40-hp size require a liquid-cooled unit. Water is normally used for cooling. When ample water is available, the water flowing from the unit is piped to a drain or sewer. Circulating cooling systems are used where water supply is critical or for operation with special coolants in freezing temperatures. Automatic systems are associated with liquid-cooled equipment to maintain constant operating temperature and to hold coolant requirements to a minimum.

Hydraulic-pump type brakes produce a braking action by virtue of the fact that they are rotating. The degree of braking is controlled by valves.

Magnetic-particle braking systems do not have common application in the steel industry, except in low power applications as in servos and instrument drives. Braking action occurs on a disk rotating in a pool of magnetic particles. Friction increases with electric excitation.

INTERNAL OR ELECTRICAL BRAKING

The various internal-braking methods can be grouped into two basic categories.

1. Countertorque systems—plugging.
2. Generating systems—dynamic and regenerative braking.

In the countertorque system, there is developed a torque which attempts to rotate the motor in a direction opposite to that existing at the time of the braking operation. If this countertorque is greater than any torques tending to keep the motor rotating, such as produced by an overhauling load, the motor will decelerate. Either a balanced speed point will be reached or the motor will go to zero speed, and if the countertorque is not removed, it will attempt to accelerate the motor in the opposite direction. The important thing to remember with this type is that a braking torque exists whether the motor is rotating or not. This characteristic is useful in applications where "stalled tensions" such as on unwind reels is needed.

Motors applicable for plugging are polyphase squirrel-cage, wound-rotor and synchronous; d-c shunt and series motors; universal and repulsion-type single-phase.

On a-c 3-phase motors, braking action is applied by reversing two of the motor leads with suitable contactors, Figure 3. The motor must be de-energized when zero speed is reached otherwise it will accelerate in the reverse direction. Losses during plugging are high. For squirrel-cage motors, losses are three times that for starting. This braking method is simple and fast operating; however, it requires the attention of an operator, timer or zero-speed switch to turn off the motor to prevent reversal of rotation at zero speed. The electric power system must be capable of supplying peak plugging current required. Motor windings may require special bracing since braking action is severe unless limited by motor series resistors.

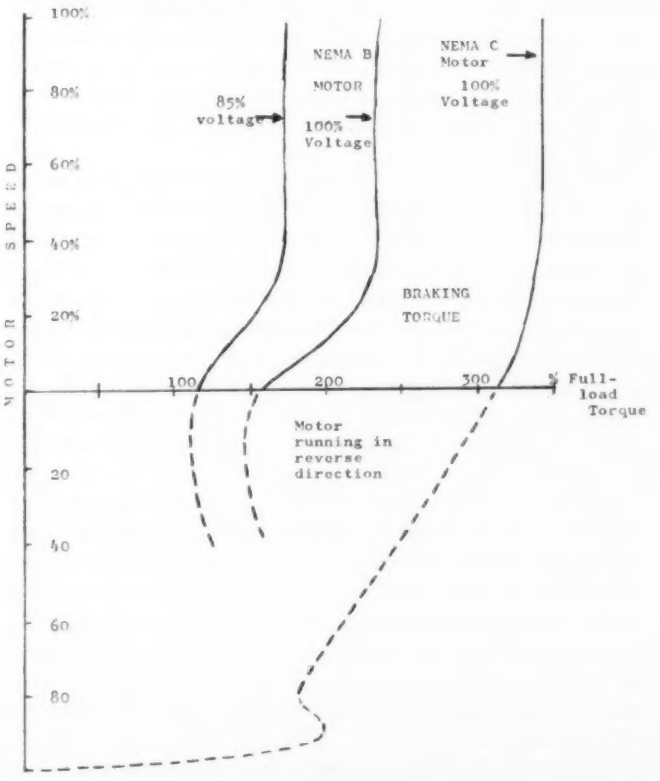
Plugging action of a wound-rotor motor is similar to that of a squirrel-cage motor. Additional control to vary the secondary resistance, produces varying degrees of braking torque. When applying plugging on very large induction motors (over several hundred hp), it is important to remember that they have open-circuit time constants ranging from several cycles to a second or more depending on their size and electrical design. (The open-circuit time constant is defined as the time it takes the motor terminal-voltage to decay to 36.8 per cent after the motor is disconnected from the line.) If the motor is reconnected to the line while a high residual voltage still exists, the inrush currents may be larger than normal, because line voltage and residual voltage may be vectorially additive at the instant of reconnection. These extra large inrush currents cause higher-than-normal mechanical stresses in the motor winding, with the possibility of reducing motor life. The problem is more severe for larger machines because they have longer coil extensions, greater concentrations of current and more critical insulation systems.

The recommended controller for plug stopping a large squirrel-cage motor usually includes a potential inter-

TABLE I
Control Size for Three Braking Methods

NEMA size	Line voltage	Recommended Maximum Horsepower		
		Friction brake and standard control	Plugging	D-c dynamic braking
1	110	3	2	
	220	5	3	3
	440	7½	5	5
2	110	7½	5	
	220	15	10	15
	440	25	15	25
3	110	15	10	
	220	30	20	30
	440	50	30	50

Figure 4 — Typical plugging-braking characteristics for squirrel-cage motors.



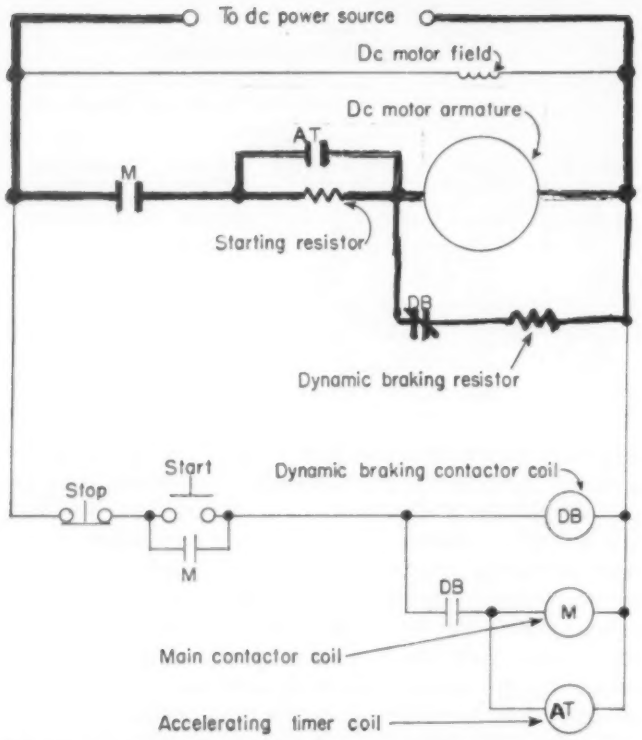


Figure 5 — Simplified schematic shows dynamic braking with resistance on a d-c shunt-wound motor.

locking relay which prevents the plugging contactor from closing until motor residual voltage has decayed to 40 to 25 per cent of full voltage.

The motor speed as well as rotor resistance also affect the rate of voltage decay. A load on the machine will help to slow down the motor when de-energized, reducing the open-circuit time constant. In the case of a wound-rotor induction motor, the insertion of the secondary resistance facilitates the dissipation of the residual voltage.

Even if the motor time constant is short, sufficient time must still be taken after opening the line contactor to extinguish the power arc before closing the plugging contactor, otherwise a short-circuit may develop. When required, current interlocking is used to insure against this happening.

Contactor sizes may be affected when applying plugging. Table I shows how the size of an a-c linestarter must be derated when applying plugging. If a machine is driven by a 5-hp, 220-volt motor, a size 1 reversing linestarter control would be inadequate for plugging service. A size 2 reversing starter must be specified.

When plugging is applied on a d-c motor, an additional armature plugging resistor is required to limit the motor current to a safe value that can be handled by the motor commutator. A value of 150 per cent of full-load current is a typical limit.

Figure 4 illustrates typical braking torques for squirrel-cage motors at different motor speeds. These are shown for rated voltage conditions. Note that different rotor designs produce different values of braking effort. Torque values can be reduced by lowering the applied voltage. On a-c motors, the torque is proportional to the square of the applied voltage. On d-c shunt motors, the torque varies directly with the applied voltage.

Generating-braking systems—In the generating internal-braking method (dynamic and regenerative) torques are developed within the motor by virtue of the fact that it is rotating. (External braking systems falling in this category are eddy current in effect, an electric motor and hydraulic—in effect, a hydraulic pump.) Two features differentiate the dynamic braking systems from the regenerative braking systems. First, dynamic braking occurs at all motor speeds. Most applications involve dynamic braking from normal speed and below. Braking is a function of the motor speed, with torques disappearing at zero (or near zero) speed. Regenerative braking occurs only at motor speeds above the normal operating speed of the motor (synchronous speed in the case of an a-c motor). The overspeed is caused by either imposing a torque (overhauling load) on the motor to speed it up, or by changing the normal operating speed, such as could occur with a two-speed a-c motor (or reduction of the supply voltage in the case of an adjustable-voltage system).

Second, with dynamic braking, the energy produced in braking is dissipated either in a connected load or within the motor itself. Motor excitation of some sort must be provided, either from a power source or generated within the motor itself. In regenerative braking, the motor is always connected to the power system, and the power produced in braking must be able to flow back into the line, or power source.

Dynamic braking with resistors is the familiar system employed in steel mills, on d-c shunt and compound-wound motors powered from constant-potential d-c shop bus, Figure 5. The motor armature is disconnected

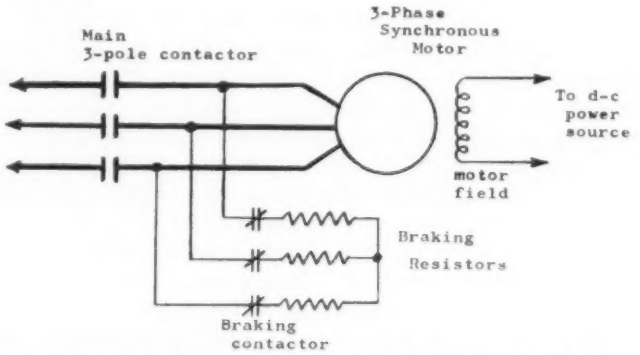
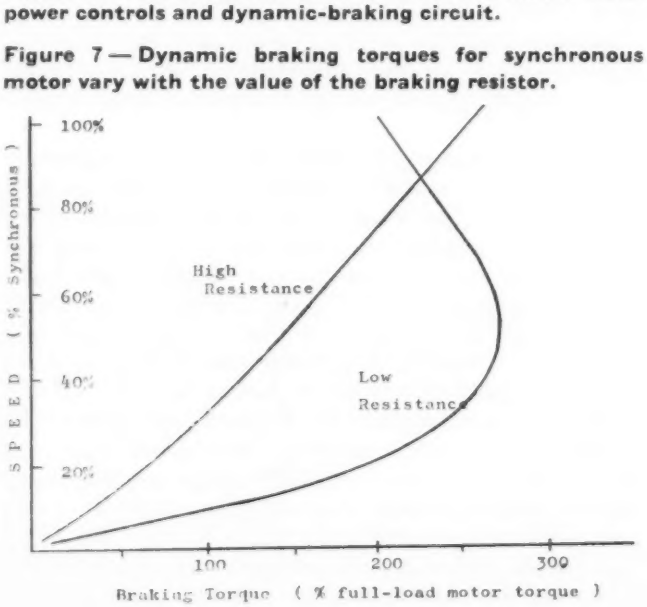


Figure 6 — Partial schematic for synchronous motor shows power controls and dynamic-braking circuit.

Figure 7 — Dynamic braking torques for synchronous motor vary with the value of the braking resistor.



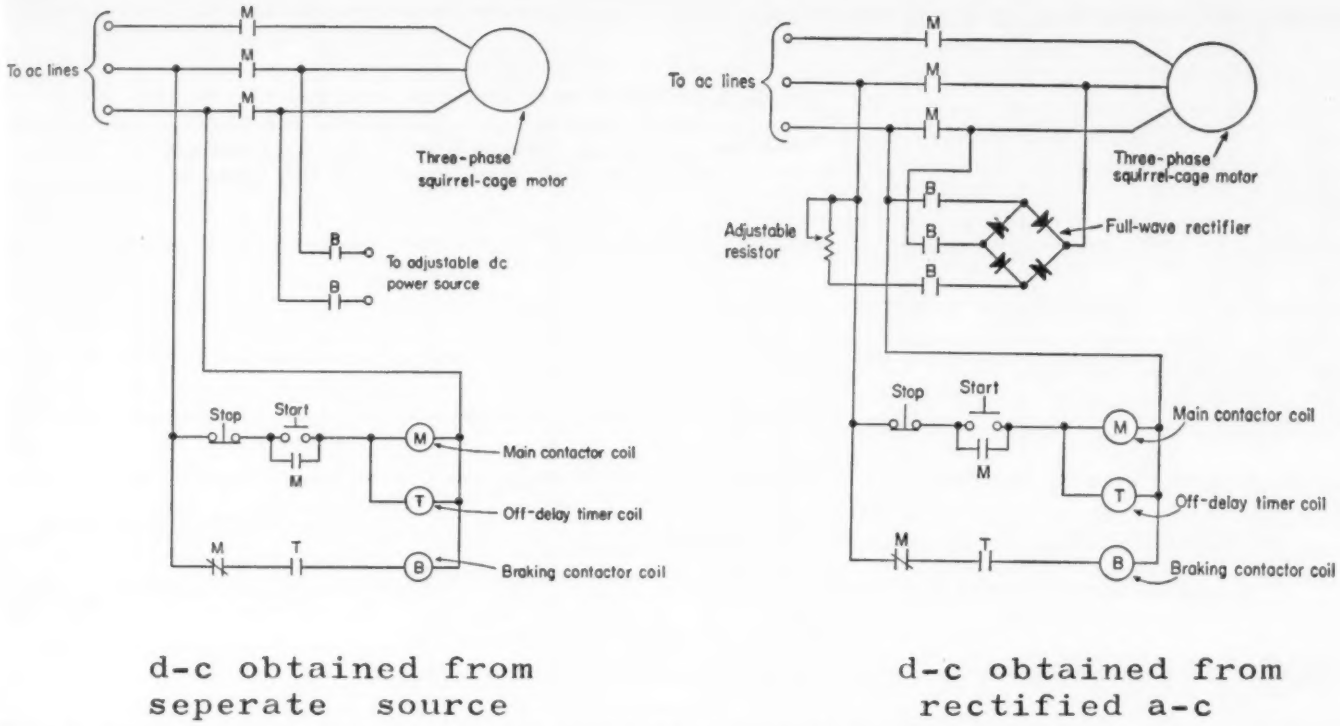


Figure 8 — Typical schemes of dynamic braking by applying d-c to squirrel-cage motors.

from the line and connected to a dynamic-braking resistor. At the same time the field is strengthened if a field rheostat is in the circuit. Energy is dissipated in the resistor. The lower the braking resistance, the shorter the stopping time. A practical limit is reached when the armature current peak reaches the commutating limit of the machine (usually from 150 to 250 per cent of rated current). To obtain higher average braking torques, a multipoint dynamic braking control may be used, since lower values of resistance are needed to maintain the high armature braking current as the motor slows down.

Synchronous motors employ dynamic braking with resistors, Figure 6. Dynamic braking is accomplished by disconnecting the motor stator windings from the line and reconnecting them across a resistor. Field excitation is maintained and the motor acts as a synchronous generator and transfers the energy of rotation into the resistor where it is dissipated as heat. No reversing takes place when the motor has come to a standstill.

The dynamic braking torque varies with the amount of dynamic braking resistance, Figure 7. A maximum amount of average braking torque, that is, a minimum number of revolutions between full speed and standstill, is obtained with a dynamic braking resistance of:

$$R_{DB} = \frac{X_{DT}}{\sqrt{3}} \text{ ohms}$$

X_{DT} is the transient reactance of the motor in the direct axis. This value is usually obtained from the motor designer.

Synchronous motors can also be plug stopped; however, because of the inherent additional delays due to potential interlocking (see counter torque braking of large induction motors) and need for maintained a-c power during stopping, dynamic braking is preferred.

Dynamic braking with d-c excitation—Braking torques can be developed by applying d-c to one phase of a squirrel-cage or wound-rotor motor after the removal of the a-c power. When the stop button is pressed, the braking contactor is energized to connect the d-c power to one phase of the motor primary winding (Figure 8). The motor then acts like a generator and is loaded by the induced current flowing through the rotor winding. This method of braking provides high maximum torque with low losses. The losses in braking from full speed to zero are approximately the same as losses developed during starting. The braking torque is low at high speeds for motors of normal slip, Figure 9. A high-peak torque develops at approximately 10 per cent speed. On large motors (400 hp, etc.) the shaft must be stiff enough so that the d-c flux will not pull the armature sideways and cause rubbing. The value of d-c is usually two to three times full load current, but may be higher for quick stopping. The use of the high-slip rotor (as in a NEMA D motor) results in much higher average-braking-torque for a given value of d-c excitation.

The d-c excitation for motors 25 hp and under is usually provided by rectified alternating current. A time delay relay is normally required to remove the direct current after motor comes to a stop. Shop bus or separate generators are used on larger applications. On a typical slabbing mill motor-generator set with an 8000-hp, 13,000-volt, wound-rotor drive motor, a separate 100-kw, a-c to d-c set is used for dynamic-braking power. The 100-kw set is only started up at the time when the large motor-generator set is to be shut down.

Dynamic braking with a-c excitation—A-c excitation can also be applied to an induction motor to provide a dynamic braking torque, Figure 10. When used in crane controls, and hoists, this braking method is usually referred to as "a-c dynamic lowering." To obtain the retarding effect, single-phase a-c is connected to one phase of the motor primary while another phase is

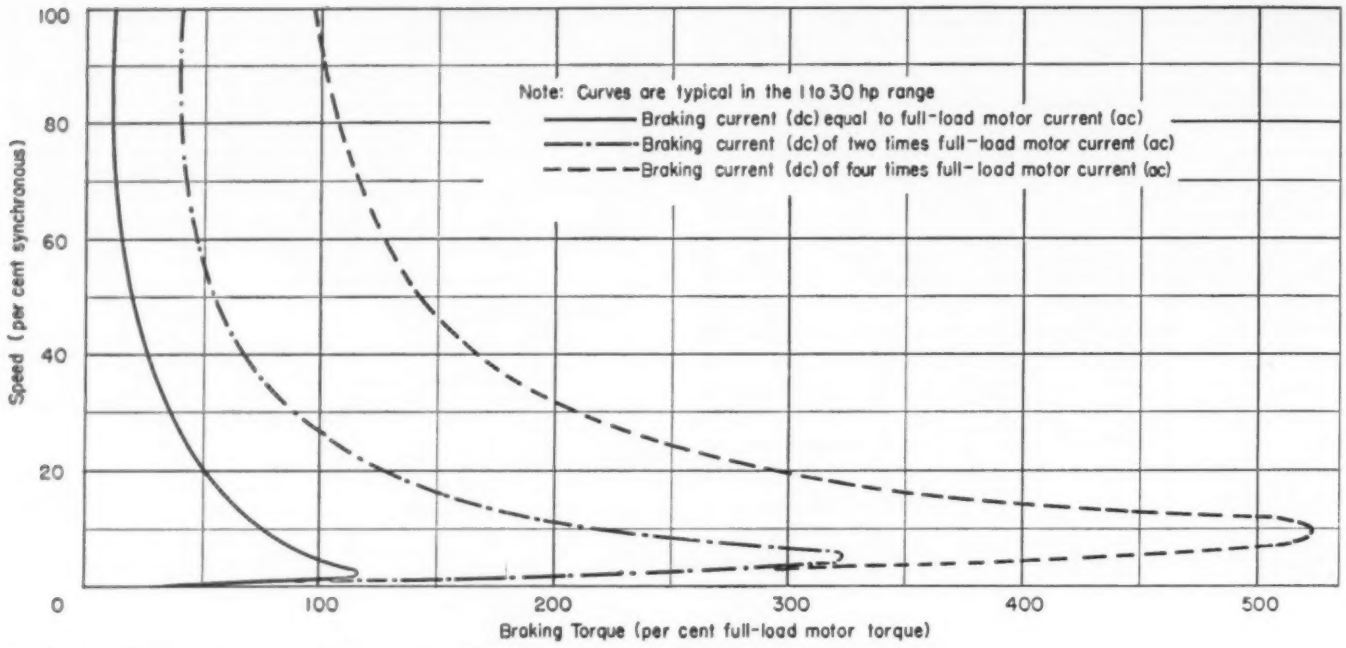


Figure 9 — Braking curves for dynamic braking by d-c excitation on induction motors.

shorted by a contactor, Figure 11. Such a connection produces a pulsating magnetic field in place of the usual revolving field. As the rotor is turned in this pulsating field, current is generated and flows through the rotor winding (and the secondary resistance in the case of a wound-rotor motor). This circuit produces an electrical retardation of the overhauling load. Different retarding torques can be obtained by using different values of resistance in the rotor circuit of a wound-rotor motor (or different values of a-c voltage if applied to a squirrel-cage motor.)

The braking method is simple, inexpensive and quite suitable for overhauling loads. The heating effect, however, may necessitate an oversize motor. Braking action reduces with speed and is zero at standstill. Single-phase a-c power of course must be available for braking.

Dynamic braking with special windings—Special three-phase squirrel-cage motors have been built with extra braking windings. A multipolar two-phase winding is superimposed on a standard stator winding of a squirrel-cage motor and is designed to be noninductively coupled to main motor winding. During braking, one phase of the brake winding is shorted on itself and the other phase is energized from the a-c line, Figure 12. Power from the line is required during braking, and the motor must be rotating to provide braking action. Braking windings are usually rated for intermittent duty. Braking action, Figure 13, is similar to dynamic braking by d-c excitation.

Dynamic braking with capacitors—Dynamic braking on a squirrel-cage motor can be accomplished by a capacitor-resistance circuit, Figure 14. A capacitor connected across the motor terminals supplies a leading

Figure 10 — Braking curve for dynamic braking by a-c excitation on induction motors.

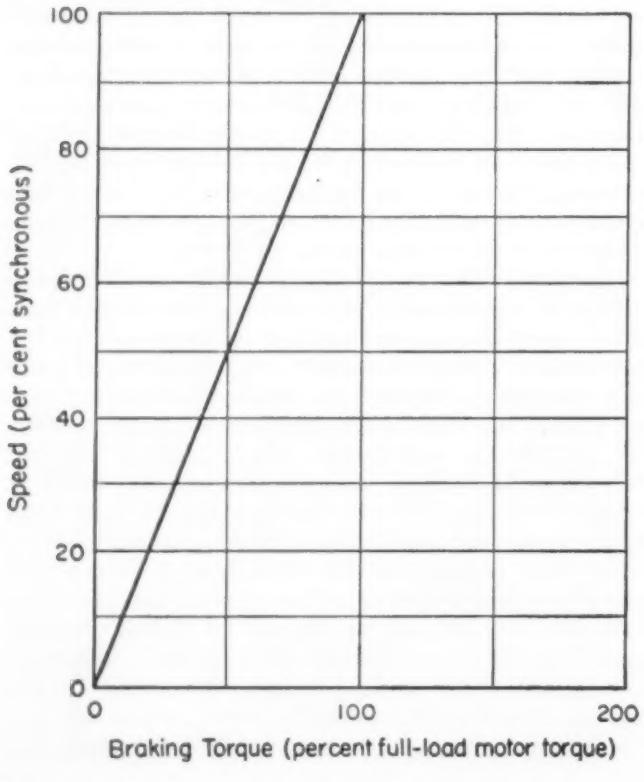
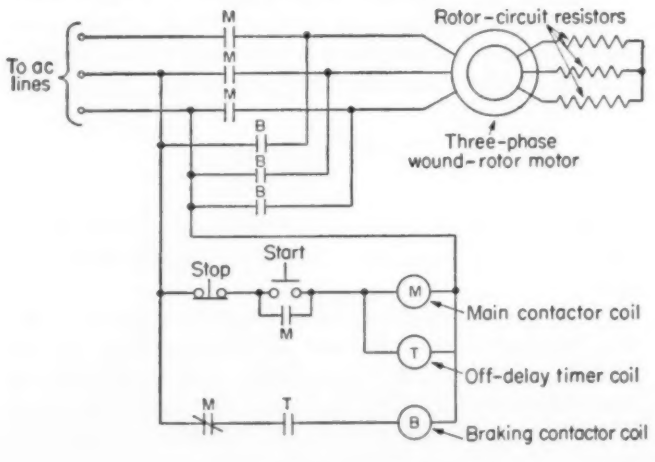


Figure 11 — Typical schematic for applying dynamic braking by a-c excitation on a wound-rotor motor.



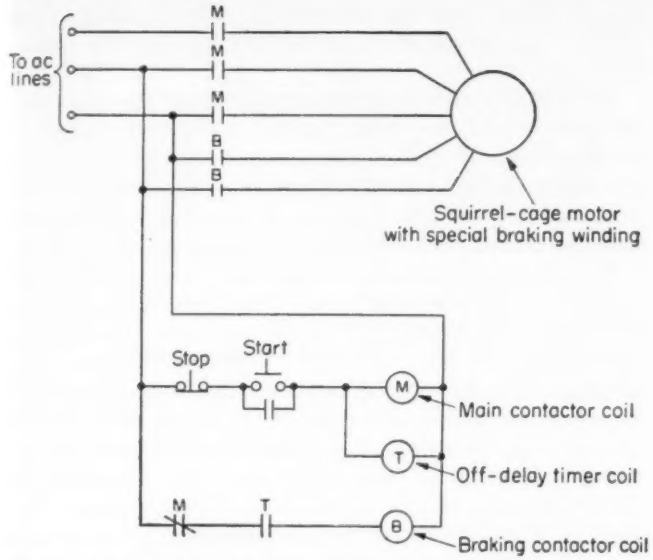


Figure 12 — Schematic for special squirrel-cage motor with built-in braking winding.

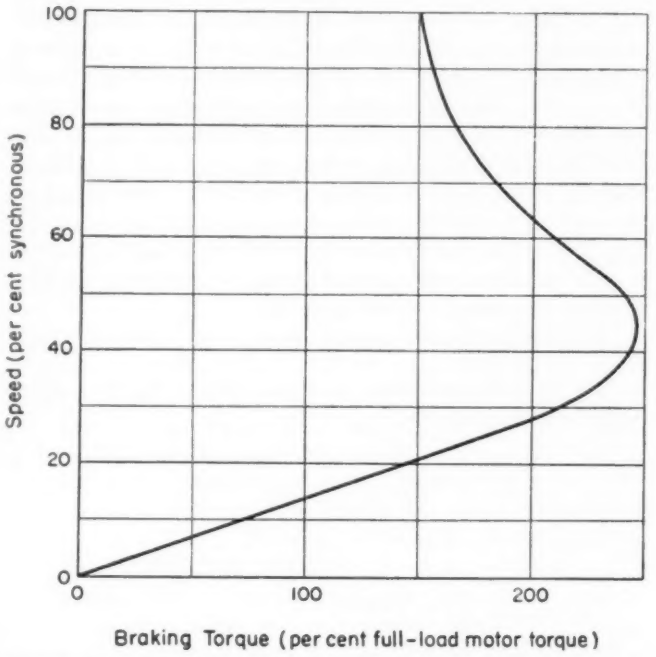


Figure 13 — Braking action for special squirrel-cage motor with built-in braking winding.

current which serves as excitation to provide dynamic braking when the run-contactor opens. Braking torque is increased by proper use of loading resistors in addition to the capacitors, Figure 15.

Braking action is independent of voltage failure of power supply. Very little maintenance is required. Braking action, however, disappears at about one-third motor speed. Capacitors for sufficient braking usually provides a leading power factor to the system.

In another interesting application, Figure 16, a capacitor is charged through the rectifier circuit while the motor is running. For stopping, the main contactor interlock connects the capacitor to the motor and it discharges d-c current through the winding to give effective braking. This system differs from the other capacitor braking method in that d-c power discharging from the capacitor is applied to the motor winding. This method is contrasted to dynamic braking by d-c excitation where a constant d-c voltage is applied and braking torque actually increases as speed decreases to about 10 to 20 per cent of normal speed. The d-c capacitor discharge method starts with maximum voltage at maximum speed which then decreases with speed to give essentially straight-line braking torque, Figure 17. The d-c power flows only until the capacitor is discharged. By proper proportioning of capacitor values to motor and load characteristics, time constants can be obtained so that the discharge time equals the deceleration time.

No electric power is required during braking because energy stored in the capacitor supplies braking power. Unfortunately, very large capacitors are required. For example, a ½-hp, 440-volt, 1800-rpm motor requires 2500 microfarad, 250-volt capacitors for a stopping time of about one second.

Regnerative braking—In many cases, special circuitry is not required to obtain regenerative braking. The only requirement being that the motor is connected to the power source. In the case of a two-speed a-c motor, when switching from high speed to low speed, regenerative braking takes place to decelerate the motor quickly to the lower speed. On some applications, such as high-inertia fans driven by multi-speed motors, the effects of regenerative braking when changing from high speed

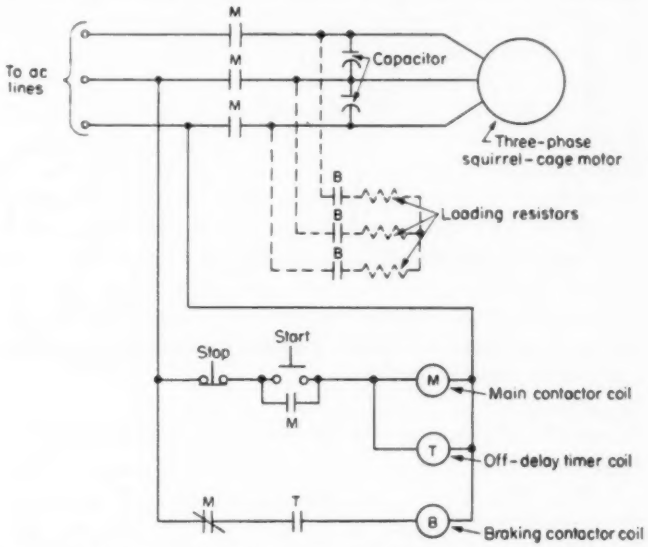
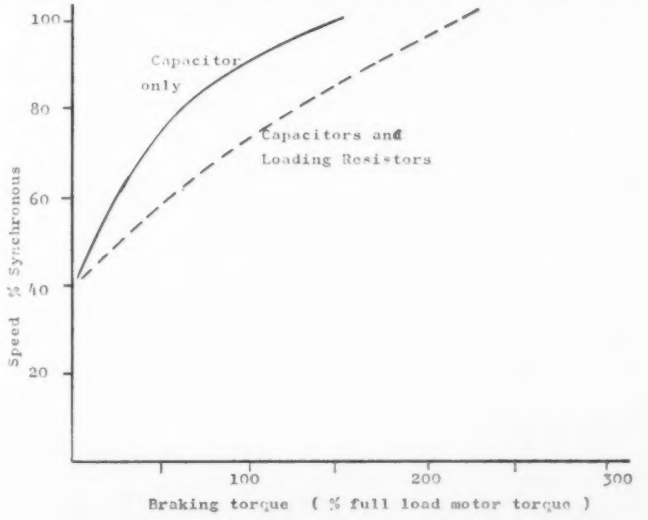


Figure 14 — Schematic for dynamic braking with capacitors.

Figure 15 — Curves for dynamic braking with capacitors.



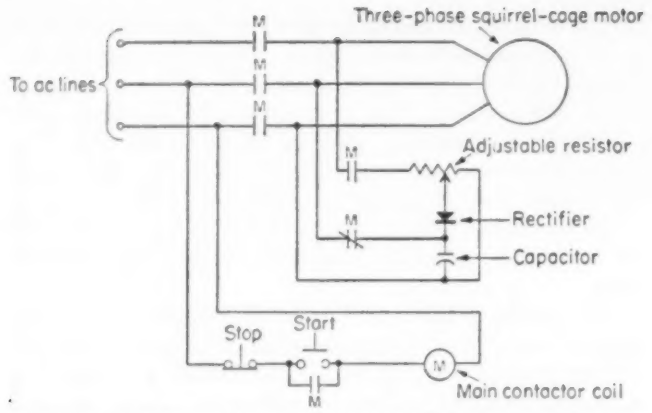


Figure 16 — Schematic for dynamic braking by d-c charged capacitor.

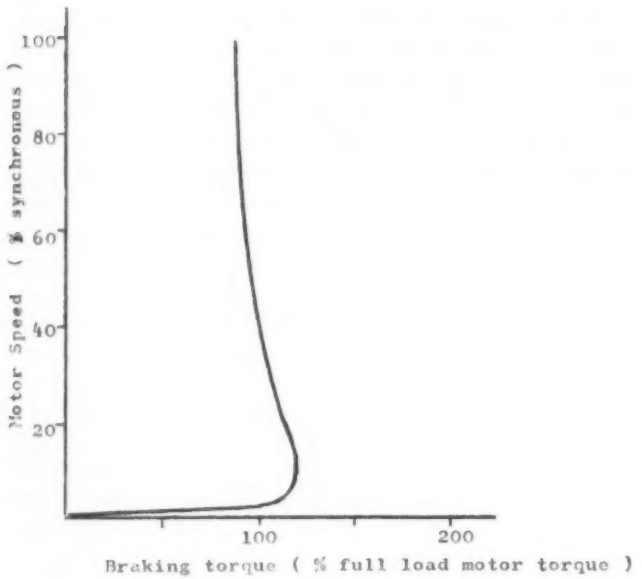
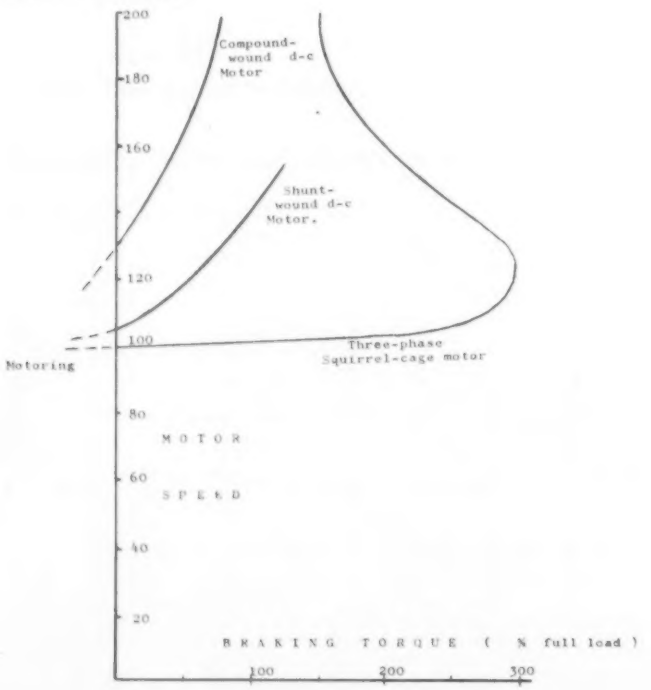


Figure 17 — Dynamic braking action for induction motor and d-c charged capacitor.

Figure 18 — Typical curves for regenerative braking of a-c and d-c motors.



to low speed may be undesirable. The braking effect may be so severe as to cause damage to the equipment.

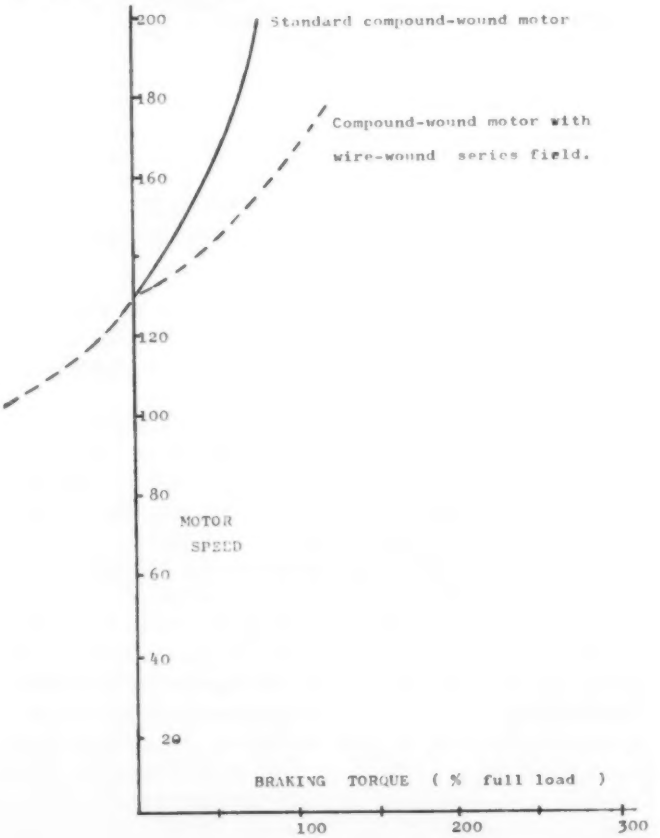
In an adjustable-voltage system, when the generator voltage is reduced, the normal operating speed is changed and the motor slows down to the lower-voltage operating speed by regenerative braking. Regenerative braking torques are high with relatively low motor losses as compared to counter torque systems, Figure 18.

On constant potential power systems, when compound-wound d-c motors are used to drive material handling applications such as car dumpers, the regenerative-braking effect drops off considerably when overhauling loads are imposed on the drive motor. Since the motor-current flow is in the reverse direction during overhauling conditions, the motor flux developed by the series field actually counteracts the flux developed by the shunt field, resulting in a weak braking action, Figure 19. This can cause serious overspeeds. Improved braking action occurs if the series field is shorted-out with a contactor during overhauling conditions.

Figure 20 shows a better system to utilize the series field during motor-current reversal. The compound-wound motor must first be designed with a wire-wound series field (S1-S2). This field then obtains its power from a resistor (R) in series with the motor armature (A). By means of a rectifier (Rec) the direction of current flow through the wire-wound series field is always the same regardless of the direction of current flow through (R) and the motor armature. In this way the motor flux from the series field is always adding to the motor flux from the shunt field. Improved braking torques are obtained, Figure 19.

In addition to its operating advantages and power

Figure 19 — Regenerative braking curves for d-c compound-wound motors.



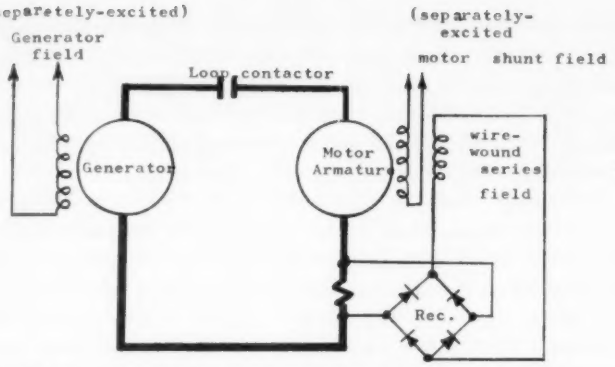


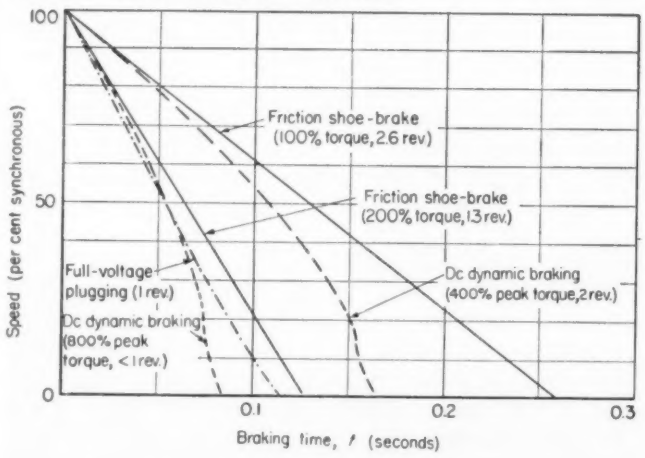
Figure 20 — Simplified schematic shows the use of a wire-wound series field and rectifier to automatically maintain maximum motor field flux during reversing and regenerative braking.

system economies, a Ward Leonard or adjustable voltage drive can provide stopping improvements over a constant potential drive, by using regenerative braking. Stopping is initiated by decreasing the generator field current and the resultant generator voltage. The motor momentarily acts as a generator and power is transferred through the motor-generator set back to the power line. In applications where the generator is driven by something other than an electric motor (a diesel for instance), it must be kept in mind that the driving machine must absorb the power, without overspeeding itself.

On a simple adjustable-voltage scheme, regenerative braking drops off below 50 volts generator output (on a normal 230-volt generator) or when the generator field voltage goes to zero since residual voltage usually exists on the generator. This can be overcome by using a generator with a "killer-field" which is in opposition to the normal generator field and drives the generator voltage to zero, by overcoming the residual effect.

Regenerative braking as employed in adjustable-voltage systems can provide extremely accurate braking control by means of suitable regulators and speed detection. Multi-motor drives, where several d-c motors are powered by the same adjustable-voltage generator, can be synchronized quite accurately with regenerative braking.

Figure 21 — Comparison of various braking methods applied to a typical squirrel-cage motor. Braking torque is in per cent of full-load motor torque and revolutions marked with each curve are number of times motor shaft revolved after braking was initiated.



In summary, following are motor-running conditions when regenerative braking occurs:

A-C systems

1. Motors are caused to run faster than their synchronous speed by an overhauling load.
2. Multi-speed motors are reconnected to operate at a lower synchronous speed (2-pole to 4-pole or 3600 rpm reconnected to run 1800 rpm).

D-C systems

1. Shunt-wound or compound wound motors are caused to run faster than their normal no-load speed.
2. Shunt-wound motors, operating with weak field and high speed, are caused to slow down by increasing the voltage on the field.
3. The armature voltage is reduced. Motor field excitation remains constant as is achieved in an adjustable voltage or Ward Leonard system.

Magnitude of braking currents and the length-of-time they exist in the motor must be considered when applying internal-electric braking. Except for a-c plugging, most current magnitudes are in the same order as those encountered in accelerating the motor. On d-c motors, the current peaks during braking should be no higher than what the commutator can handle. A value of 150 per cent of full load current is a typical limit, however, some motors can handle more. On high-inertia applications braking time may be long. The heat dissipation of a motor reduces as the motor speed reduces (except for force-ventilated motors), consequently, if a counter-torque system or dynamic braking system is applied for some duration at reduced motor speeds, such as on unwind reels requiring tension, detailed information should be given to the motor manufacturer so that the motor will be designed to avoid overheating.

COMBINING BRAKING METHODS

When no single braking method provides all the requirements of an application, then two or more methods can be combined to satisfy a given application. On elevators, cranes, conveyors using d-c motors, for example, shoe brakes are combined with regenerative and dynamic braking. On overspeeds, regenerative braking takes over; on power failure dynamic braking is applied (the motor field excitation must be maintained). When speed has reduced to a low value where the dynamic braking is no longer effective, the shoe brakes are engaged. A voltage or speed-sensing relay is used in the control circuit to apply the shoe brake after the motor has slowed down to nearly standstill. This conserves the brake-shoe linings.

A new rail-clamp control for ore bridges combines two systems to provide safe, economical braking. As the control scheme shows, Figure 2, after hoisting the rail-clamp weight, the squirrel-cage motor is held up by means of the shoe brake. When lowering, the shoe brake is released and dynamic braking by capacitors takes over to provide a safe, slow lowering speed, even with the rail-clamp weight attempting to overspeed the motor in that direction.

With adjustable-voltage drives on process lines, regenerative braking can be used on the uncoiler to

maintain strip tension control while the line is in operation. At standstill, countertorque is used to maintain tension on the strip.

COMPARING COSTS

In comparing first costs of braking methods, it is important to examine comparable braking results. In some horsepower ranges, shoe-brake applications are approximately the same price as plugging where shoe-brake torques are applied at 100 per cent of the motor full-load torque and plugging is applied at full voltage. The graph in Figure 21 shows that full-voltage plugging will stop a motor in about half the time that a 100 per cent torque friction shoe-brake would. To obtain the same stopping time as plugging, the shoe-brake would have to be twice the capacity, which would make plugging lower in first cost. However, if reduced-voltage plugging were applied to make the plugging time comparable to the 100 per cent torque shoe-brake, the additional control would cause the plugging system to become more expensive than the shoe-brake.

Actually there is a price to pay for every braking function. Mechanical brakes may be the least expensive, however they are not very versatile. Friction type brakes have the disadvantage of requiring maintenance on parts such as the shoe linings. Highly-controlled internal braking systems may be more expensive, but they do provide many more braking functions. In the final analysis, the most economical braking system is the one that best serves the needs of the application. ▲

Available Translations

As a service to readers of the *Iron and Steel Engineer* a list of translations from foreign articles is being printed intermittently. Articles selected for this listing will be those of primary interest to the American steel plant operator. The papers may be obtained from the British Iron and Steel Industry Translation Service, The Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W. 1, England. All correspondence concerning price, ordering and so forth should be directed to that address.

1256 WICKE, E., et al.: "Reduction of Fine Ores in Two Stages by Carbon Monoxide (CO-C-Iron Process)," *Stahl u. Eisen*, 1959, Feb. 5, pp. 129–134. The outlines of a new direct reduction process (CO-O-iron process) carried out in two separate steps, based on the already well known turbulent zone processes, are described. The first stage consists of the precipitation of carbon on the ore in a turbulent zone with carbon monoxide. In the second stage the product of the first stage is reduced by ordinary heating to iron during which some of the carbon monoxide used up in the first stage can be recovered. Carbon precipitation on tests (first stage) gave an optimum temperature of 550 C, at which more than 60 per cent of the carbon monoxide was decomposed during its passage through the turbulence zone. The heat generation of the exothermal reaction proved to be adequate for maintaining the required temperature. The carbon precipitation was accompanied by a simultaneous reduction of the ore to about a Gross FeO composition. The product of the first stage was rapidly converted into iron and carbon monoxide at temperatures above 800 degrees (second stage). Comparison tests confirmed that reduction potential of the carbon precipitate on the ore was far greater than that of fine coke breeze or activated coal in a fine ore mixture. Several practical technical applications of the process are discussed with the aid of material and heat balances. One process seems to represent a particularly attractive thermo-economical proposition, for which the heat given off during the gas formation is utilized in the second stage of the process. (Author's summary.)

1311 SMIRNOV, V. S.: "The Deformation Process in Cross Rolling," *Stal'*, 1947, June, pp. 511–518.

1176 WINTERKAMP, H.: "Production of Hot Rolled Wide Strip with Particular Reference to the Steckel Mill," *Stahl u. Eisen*, 1954, Nov. 4, pp. 1492–1502. Methods used at several American plants for producing hot rolled steel strip are described and compared. The types of steel employed, soaking-pit and slabbing procedures, slab heating furnaces, and hot rolling mill operation are described. Methods of testing and production planning are discussed. (Abstract J.I.S.I., 1955, July, p. 311.)

1282 GAGIN, S. D.: "The Efficiency of Electric Steel Production by the Duplex Method of Oxygen Converter and Electric Furnace," *Kislorod* (Moscow), 1957 (6), pp. 1–11. Conversion to duplex working is described and many results are tabulated. It is concluded that a cost reduction of three to seven per cent with a reduced capital investment of 12.2 to 15.8 per cent could be expected. The supply of scrap was improved, furnace productivity could be doubled and the duplexing method gave more flexible working and better synchronization than open hearth-electric furnace working. Top blowing with O_2 gave adequate dephosphorization. (I.S.I. abstract.)

1300 RAUSCH, W.: "The Chemical Surface Treatment of Steel Strip to give a Better Protection against Corrosion, Greater Adhesive Strength of Coatings and Formation of Insulating Layers," *Stahl u. Eisen*, 1959, Mar. 19, pp. 349–356.

1351 MISE, S., et al.: "Metal Flow in Oblique Rolling," *Sumitomo Metals*, 1957, July, pp. 143–157.

1164 SPETZLER, E.: "The Rotor Process," *Neue Hutte*, 1958, Feb., pp. 85–93. Design of the rotor —metallurgy of the rotor process—steel production—control of the refining process—heating arrangements—furnace lining—cleaning the waste gases—quality of steel—efficiency. (Author's summary.)

Design Data for Bearings of Nylon, Acetal, and TFE Fluorocarbon Resins

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THE plastics industry is maturing, and has now reached a point where many of its products can be truly classified as engineering materials. Performance of plastic parts can now be predicted more accurately on the basis of previous experience, or experimental data. By the same token, information now available to the designer enables him to design plastic parts with confidence.

Temperature and deformation with time are not major factors in dealing with metals. To the plastics engineer, however, these must always be considered. In the last few years only have data and experience been accumulated which allow him to compensate in design for the effects of such variables.

In the field of bearings, there are three plastics for which an intensive study of these design factors has been made. They are nylon TFE-fluorocarbon resins and, most recently, acetal resin. While not complete, sufficient information has been gathered to enable the engineer to design a plastic journal bearing with confidence in its successful performance.

. . . . with low friction, high load and low speed, teflon is the logical first consideration; if abrasion resistance governs, nylon resins should be considered; if maximum resistance to creep is desired, acetal resins or teflon fabrics are indicated as the most suitable bearing material . . . .

The word "steel" designates a group of iron compositions. Similarly, the term "nylon" designates a family of polymers. This is true also of acetal resin and TFE-fluorocarbon resins. The design information presented in this paper is based on data and know-how obtained with specific compositions of these generic groups, best fitted for bearing applications. These are: "zytel" 101 nylon resin, "delrin" 500X acetal resin, and various reinforced compositions of "teflon" TFE-fluorocarbon resins.

PROPERTIES OF PLASTIC BEARING MATERIALS

Before discussing the design of journal bearings using these materials, let us look at some of their physical properties to help us understand why bearings are a prime field of application for them.

Table I illustrates the nature of materials under consideration. For example, all three are low conductors of heat. They all have approximately the same coefficient of thermal conductivity, although the addition of certain reinforcing materials to "teflon" TFE resins significantly changes this property.

"Delrin" acetal resin has the highest yield point. Although decreasing slowly as the temperature increases, at 200 F the yield point is still approximately 6000 psi.

The yield points of the reinforced compositions of "teflon" TFE resins are lower than those of the other two materials, and vary considerably with the percentage and type of reinforcement. Typical reinforcing materials are: glass graphite, copper and asbestos. Loadings vary from 10 to 50 per cent by volume. From the standpoint of compressive strength alone, glass is one of the best additives.

A recent development of interest in bearing applications is the weaving of oriented fibers of "teflon" TFE resin into a fabric. Oriented fibers show increased tensile strength. This fabric is being used as a bearing material. While properties are not included in Table I they are available.

It can also be seen in Table I that the compositions of "teflon" TFE resins have the highest upper service temperatures. In many applications, this is a major design requirement.

The Taber abrasion measurement is one indication of wearing quality. It is not a measure of bearing per-

TABLE I
Available Properties

Properties	"Zytel" 101 nylon resin at 2½ per cent moisture	"Delrin" 500X acetal resin	Reinforced "Teflon" TFE* resin
Yield point at 73 F (psi)	8,500	10,000	850 to 1800
Upper temperature limit for continuous service (F)	250	180	500
Taber abrasion (mg after 1000 cycles from 1000 gram load and CS-17 wheel)	6 to 8	20	8 to 50
Rockwell hardness	M59, R108	M94, R120	J63 to 80
Coefficient of thermal conductivity (Btu per in. per hr per ft² per °F)	1.7	1.6	1.7 to 20.0
Compressive stress at 1 per cent strain at 73 F (psi)	2,000	5,200	100 to 200
Flexural modulus at 73 F (psi)	175,000	410,000	125,000 to 200,000
Coefficient of linear thermal expansion (in. per in. per F)	5.0×10^{-5}	4.5×10^{-5}	2.0 to 5.0×10^{-5}

*** Widespread of values is due to the numerous reinforcing materials and varying percentages of concentration. Properties of TFE fiber bearings are not included and are available upon request.**

formance, but shows only a relative abrasion resistance. The only true measure of abrasion resistance is by actual use testing. All three plastic materials show similar values in the Taber test; but in actual service, "lytel" nylon resin usually shows the greatest abrasion resistance.

The material properties are different. "Delrin" acetal resin is the hardest and most rigid, with a modulus of 410,000 psi at 73 F. "Zytel" nylon resin, however, is a tougher resin as exhibited by its lower modulus, and high yield point. "Teflon" TFE resins have uniquely low frictional properties, lower than any other nonlubricated material.

BEARING LUBRICATION

Most plastic bearings operate dry, or with only initial lubrication. Occasionally, there are instances where plastics are used with complete hydrodynamic lubrication. When plastic materials are selected for completely lubricated service, it is often for a supplementary reason. For example, "zytel" nylon and "delrin" acetal resins will retain hydrodynamic lubrication with a minimum of lubricant (1).* This property is particularly desirable if there is a possibility of improper lubrication at operating conditions above the capabilities of a dry bearing.

The procedure for designing a fully lubricated bearing is more dependent on the properties of the lubricant than upon the properties of the bearing material. This is true of hydrodynamically lubricated metal bearings as well as plastic bearings. As such, this facet of bearing design falls outside the scope of this paper.

* Numbers refer to Bibliography at end of paper.

TABLE II
Dynamic Friction of Dry Bearings Against Steel

Material	Dynamic coefficient of friction
"Zytel" 101 nylon resin	0.20 to 0.40
"Delrin" 500X acetal resin	0.15 to 0.35
"Teflon" TFE fluorocarbon resin (reinforced compositions)	0.10 to 0.25 (up to 100 fpm) 0.10 to 0.45 (loads less than 25 psi)

The design information presented here is for dry, sleeve type, journal bearings. Although the data apply specifically to sleeve bearings, it appears that they can also be used conservatively for plane surface bearings.

In this paper, the term "dry" means solvent cleaned. In the test work upon which this design approach was based, the bearings and shafts were cleaned with carbon tetrachloride to remove any traces of oil, since even a minute quantity of oil will improve the bearing characteristics of these materials. The design engineer can be confident that any oil on the bearing or on the shaft will contribute to even better performance.

FRICTION

Friction is of prime concern to the bearing designer. As yet, it is impossible to predict accurately a specific coefficient for a specific bearing. However, enough data have been accumulated (see Table II) to indicate the approximate levels of friction under most bearing conditions.

Bearings of a reinforced "teflon" TFE resin have a lower coefficient, in the range of 0.10 to 0.25 for speeds up to 100 fpm (3, 4). For velocities above 250 fpm the coefficient will level out at 0.26. At light loads, less than 2 psi, the coefficient will be as high as 0.45. "Teflon" has an exceptionally low coefficient at speeds lower than 20 fpm and at loads higher than 25 psi. Under such conditions, coefficients as low as 0.05 can be attained with compositions containing a low percentage of reinforcing additive. Unfilled "teflon" TFE resins against steel have the lowest coefficients of all materials, as low as 0.04. The static coefficient of "teflon" TFE resin is less than the dynamic coefficient of friction. Consequently, there is no slip-stick. Smooth operation and easy break-away are the result. This can be an advantage where the operation is intermittent.

Dry bearings of "zytel" nylon resin will run with a coefficient of 0.20 to 0.40. Bearings of "delrin" acetal resin run with slightly less friction, in the range of 0.15 to 0.35. The static coefficient of friction of "delrin" acetal resin is equal to its dynamic coefficient.

LOAD AND SPEED

"PV" is a common bearing term which is applied to the product of the velocity, in fpm and the bearing pressure in psi, over the projected bearing area. Guides to PV limits for satisfactory operation of journal bearings of the three materials under consideration are shown in Table III. In general, a length to diameter ratio of 1 to 1 is recommended for the limits shown.

Recent experimental work has more clearly defined the PV limits. While the limits shown in Table III are

TABLE III
Design PV Limits

Material	Velocity Ranges, fpm			
	0 to 100	100 to 200	200 to 400	400 to 600
"Zytel" 101 nylon resin	3,000	2600	2200	1800
"Delrin" 500X acetal resin	3,000	2600	2200	2100
"Teflon" TFE fluorocarbon resin (reinforced compositions)*	9,600	9600	9600	9600
Fabric of TFE fiber	25,000	Not recommended		

* Data reported by Dixon Corporation of Bristol, R. I.

believed to be the maximum for sustained operation, there are many bearings which exceed these values. However, since most machines are subjected occasionally to unexpected loads and vibration, it is considered good practice for the designer to limit the design PV to only 75 per cent of the rated limit, whenever possible. For example, in designing a bearing of "delrin" acetal resin to operate between 100 and 200 fpm, it would be advisable to select a PV value of 2250 which is only 75 per cent of the rated maximum value.

Two equations have been established which also permit the determination of the limiting PV factor for bearings of either "zytel" nylon or "delrin" acetal resins. For "zytel" nylon resins the limiting equation is: $PV^{1.47} = 40{,}000$. It was established for a bearing clearance of 0.015 in. per in. For bearings of "delrin" acetal resin, the equation is: $PV^{1.20} = 7600$. It applies for clearances of 0.005 in. per in. Figure 1 shows the curves of the two equations. It can be seen that both curves are essentially equal in spite of the difference in shaft clearance. With present knowledge, it is thought that both are about equal with respect to limiting PV. However, "delrin" acetal resin can probably reach the limiting conditions with slightly smaller shaft clearances since the use of minimum clearance is closely related to dimensional stability of the bearing material.

For all materials, it is recommended where practical to add several drops of oil prior to assembly.

CLEARANCE

Clearances for unsplit journal bearings are greater than for metals to compensate for dimensional changes.

Figure 1 — Curves give limiting PV values for bearing pressures vs velocity for acetal and nylon resins.

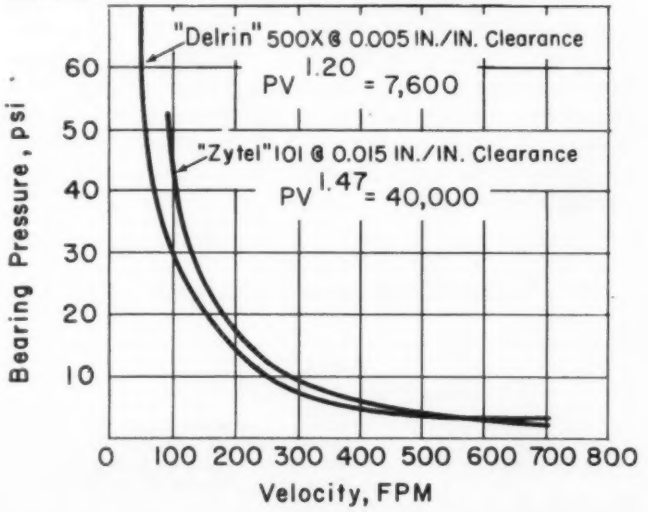


TABLE IV
Suggested Clearances

Minimum	0.005 in. per in.
Good practice	Up to 0.015 in. per in.
No less than	0.004 in. per in.

In our field work, we have found that more than 50 per cent of bearing problems are the result of insufficient clearance. Usually increasing the clearance gave the required performance. The resilience and vibration absorption of these materials aid in overcoming possible disadvantages of larger clearances.

Table IV shows suggested diametral clearance for the average installation in air at room temperature. Recent tests indicate that for best performance, bearing clearances should be 0.005 in. per in. minimum and it is preferred to specify up to 0.015 in. per in. In very few cases should a clearance of less than 0.004 in. be specified, even for bearings with small inside diameters.

TEMPERATURE

These three plastics have a coefficient of thermal expansion about ten times that of metal. In the sizing of the bearing, allowance for thermal expansion or contraction must be made, so that clearances will be maintained at the operating temperature. The dimensional changes with temperature vary with the design. For example, in a sleeve type bearing in a rigid housing,

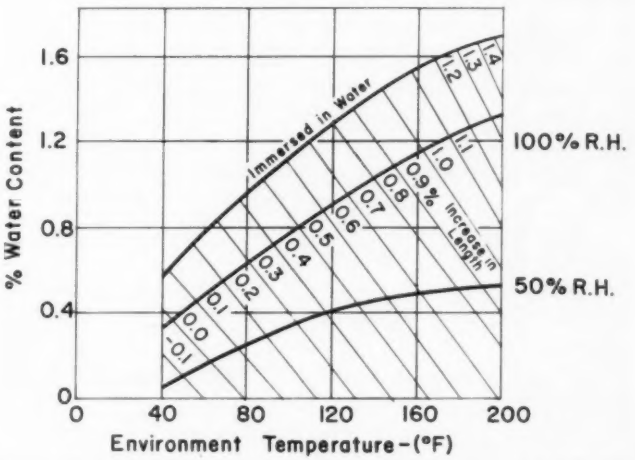
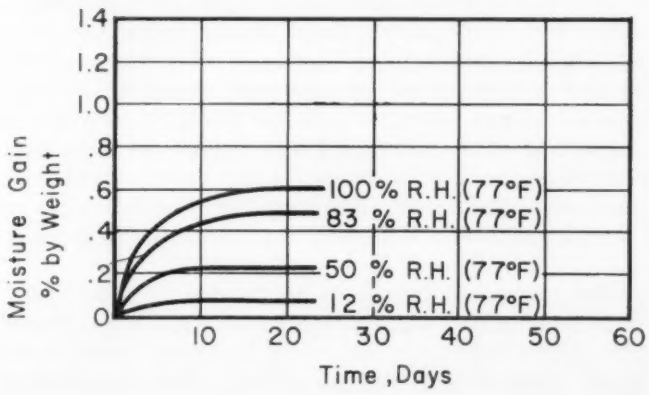


Figure 2—Curves give dimensional changes in acetal resins due to humidity and temperature.

Figure 3 — Curves show that it takes from 10 to 20 days for acetal resins to pick up moisture from humidity.



lowering the temperature 100 F will cause a contraction in the clearance of 0.005 in. per in. Raising the temperature 100 F will have little effect on the clearances. The reverse effect is true when the running surface is on the outside diameter of the sleeve. For best performance, the designer should size the bearing so that the proper clearances are obtained at the operating conditions.

MOISTURE GROWTH

An unfilled "teflon" TFE resin does not absorb water; hence, does not change dimensions with moisture variations. The reinforced compositions may be subject to dimensional changes, depending upon the nature of the additive, and the per cent loading. For example, if glass is the reinforcing material, there are no dimensional changes as glass does not absorb water. Thus the composition is unaffected.

"Delrin" acetal resin is affected only slightly by moisture. It shows excellent stability over a wide range of temperatures. However, in water service, dimensional changes should be considered in the design. Figure 2 gives a method for approximating dimensional changes due to temperature and moisture. Figure 3 indicates the time it takes for these changes to occur.

"Zytel" nylon resins will absorb moisture (from the atmosphere or anywhere else). When design clearances are 0.015 in. per in., moisture changes and resulting dimensional changes in an air environment are not a problem. However, when clearances are below 0.012 in. per in. or bearings are in water service, environmental effects should be considered in the design.

As molded, "zytel" nylon resins normally contain less than 0.3 per cent moisture by weight. Exposed to air at 73 F and 50 per cent relative humidity, moldings of "zytel" will reach an equilibrium moisture content of 2½ per cent. The rate of moisture absorption and the resulting rate of dimensional change are low as shown in Figures 4 and 5.

A technique for minimizing dimensional changes in service is to precondition the bearings for the operating environment. Boiling in water or heating in a salt solution of potassium acetate in water brings the nylon to an equilibrium moisture content at a faster rate and adjusts the bearings to the equilibrium dimensions of the anticipated service conditions (2). This can be done simply by the bearing supplier.

STRESS RELAXATION

Injection molded bearings of nylon or acetal resin may contain internal stresses induced during molding. If these are high enough they may relieve themselves at elevated temperatures and result in slight dimensional changes of the bearing. To speed up these changes, and to eliminate inservice changes with possible impaired performance, the bearings should be annealed. Leaving the annealing oil on the bearing surface will improve the bearing characteristics by serving as initial lubrication.

The annealing should be performed by immersion in a hot oil which will not oxidize or chemically attack the plastic bearings. "primol D", "nujol" and "uniflow" oils have been used successfully. The parts should

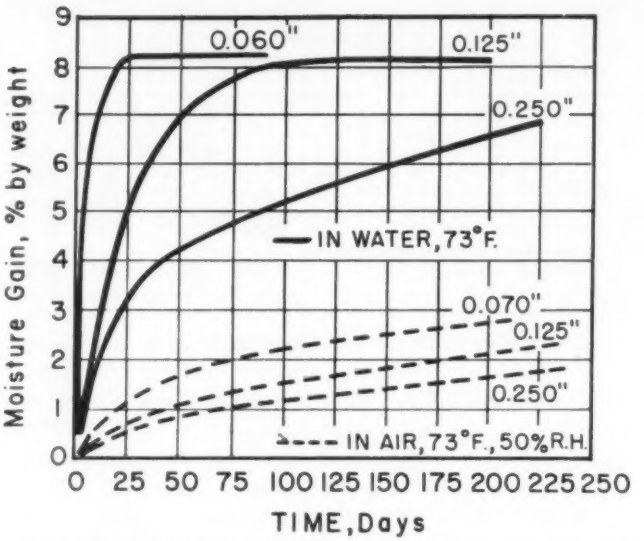


Figure 4 — Curve gives time required to pick up moisture for nylon resins.

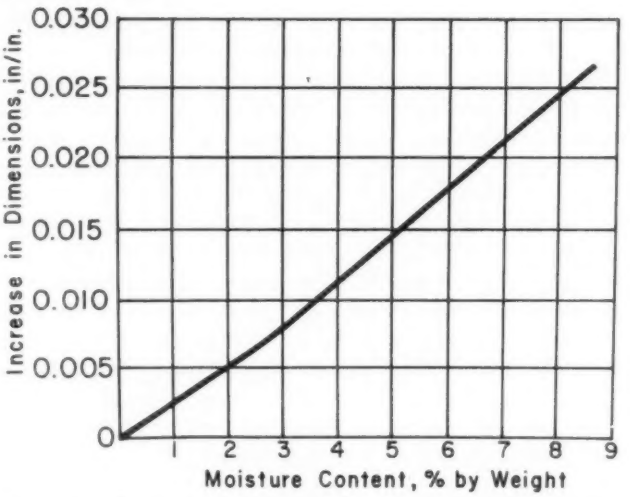


Figure 5 — Curve gives changes in dimensions of nylon resins due to moisture content.

be submerged in oil at 320 ± 3 F for a period of time equal to one minute for each 0.020 in. of thickness.

ASSEMBLY

When press fitting a bearing, allowance must be made for dimensional change during assembly. In a press fit, the interference will translate almost completely into inside diameter close-in or outside diameter expansion, depending which is the running surface. Compensation for this dimensional change should be included in the design. One of the bearings should not be constricted in the mounting. Prevention of thermal expansion in the axial direction may cause a reduction in radial clearance.

SURFACE FINISH

Table V shows recommended surface finishes. The

TABLE V
Surface Finish of Bearing and Shaft

Bearing	As molded—not critical
Steel shaft	Maximum—25 rms micro-inches
	Preferable—16 rms micro-inches

finish of the plastic surface is usually insignificant. Bearings molded with a surface finish of about 25 to 50 rms micro-inches perform as well as bearings with a highly polished, smooth finish. The "break-in" period tends to reduce all bearing finishes to one finish, for any given shaft.

It is the shaft finish which is critical because it is the harder material. A shaft finish of 25 rms micro-inches is considered to be the maximum for good wear characteristics, but one of 16 rms or less is preferable. The shaft material is usually steel, and other than for surface finish, it needs no special treatment or hardening. Other metals have been used but there is very little information available with which to define parameters for either finish or hardness.

DEFORMATION WITH TIME

The operating limits of a plastic bearing are more sensitive to velocity than to bearing pressure. However, there are compressive stress limits which should be considered in a well-designed bearing. Table VI shows the suggested design limits to be the stress levels produced at 0.5 per cent strain at 200 F.

These limits for compressive stress are only a small percentage of the compressive strengths of the materials and are purposely limited to low values to prevent excessive deformation at high temperatures. For cool, or light duty bearings, deformation is negligible. But, for bearings designed to operate near the limiting PV conditions, the design compressive stress limits should be increased only after cautious experimentation. "Delrin" acetal resin (because of its high strength and hardness) and fabric of "teflon" (due to fiber orientation) are the least likely to creep under heavy load.

The characteristic of deformation with time under load or creep is always present in plastic materials; and is a mechanism of yielding similar to that experienced with metals at high temperatures. For practical design purposes the deformation at less than 1 per cent strain after a one year period reaches a magnitude approximately equal to that of the initial strain. To estimate total elongation, the initial strain may be multiplied by two. After a year's period, the creep rate becomes insignificant and often immeasurable. Most of the creep is experienced within 1000 hr.

Figure 6 shows the basis for this method of estimation. It is a curve of apparent modulus of "delrin" acetal resin versus time at 750 psi stress and 185 F. Apparent modulus is defined as the stress divided by the sum of initial strain plus creep. It is a modulus of elasticity with an allowance for deformation under load with time. At time "zero," the apparent modulus is equal to the modulus of elasticity as determined from a stress strain diagram.

TABLE VI
Design Limits on Compressive Stress

Material	Compressive stress at 0.5 per cent strain at 200 F, psi
"Zytel" 101 nylon resin	350
"Delrin" 500X acetal resin	800
"Teflon" TFE fluorocarbon resin (reinforced composition does not include TFE fabric)	50 to 150

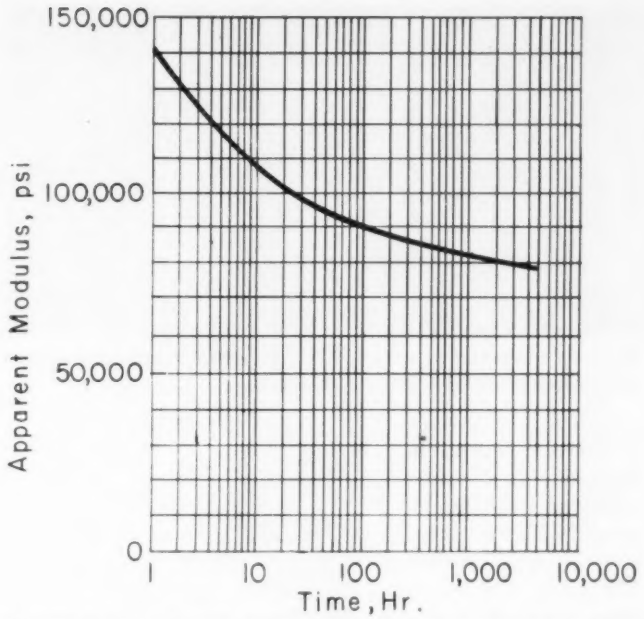


Figure 6 — Apparent modulus of acetal resins with time under load at 750 psi stress and 185 F.

SERVICE TEMPERATURE

"Zytel" nylon, "delrin" acetal and "teflon" TFE resins are normally considered to have maximum continuous environmental service temperatures of 250, 180 and 500 F, respectively. However, recent tests with "zytel" nylon and "delrin" acetal resins have indicated that the shaft temperature should not exceed 175 F when operating at recommended PV limits. Reducing the PV will permit operation at higher temperatures. This temperature limit was established by measuring the temperature at the bearing surface by means of a thermocouple positioned on the surface of the steel shaft. There is no indication that the 175 F limit applies to bearings of "teflon" TFE resins. There are successful applications at higher temperatures for "teflon."

Since the bearing surface is the source of heat, it is the hottest part of the bearing assembly. The bearing housing is usually significantly cooler than 175 F. Because of this, a general rule-of-thumb has evolved. We advocate the old saying, "If the bearing holder is too hot to handle, it is too hot to use." This may not be the most scientific approach, but it frequently can be used in evaluating new bearing applications and designs. Excessive operating temperature is probably the best indication of imminent bearing failure.

Plastic bearings should always be designed utilizing the most efficient means of transferring heat away from the bearing surface. The usual path of conductance is through the steel shaft. It is also desirable to make the bearings as thin as practical in order to increase the heat transfer rate to the housing. Thicknesses of $\frac{1}{16}$ in. or less are used successfully. If the parameters of design so far outlined in this paper are followed, excessive heat will normally not be a problem. Nevertheless, it should be remembered, a hot bearing is an indication of rapid wear.

WEAR

As yet, it is not possible to predict wear rates accurately. However, there is considerable evidence to

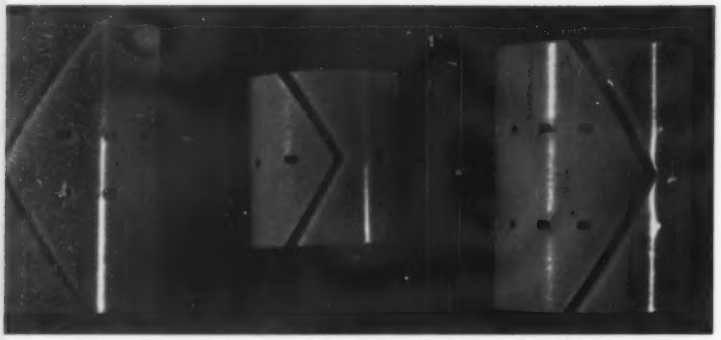


Figure 7 — Acetal resin bearings shown are split bushings for automotive steering knuckle.

indicate that properly designed bearings will wear at a rate of approximately 0.005 in. or less, in 5,000,000 cycles. Usually wear rates are considerably lower, especially if the bearings are initially lubricated. Because it is impossible to predict wear accurately, prototype testing of new bearing designs under actual or simulated service conditions is strongly recommended. This will insure a greater chance of initial success in production units. Prototype samples are relatively easy to obtain since all three materials are available as rod stock and can be machined with standard metal working tools.

Like all bearings, plastic bearings should be "broken-in" for best wear characteristics. Fifteen minutes at one-half the service conditions are usually more than satisfactory for nylon or acetal bearings. With bearings of "teflon" TFE-fluorocarbon resins, the time is even less. Very often, a 15-min break-in period is impractical from a production assembly standpoint. In such cases, it is good practice to reduce the design PV in order to lower the level of significance of the break-in period. An alternative to this is initial lubrication of the bearings with a few drops of oil. Or, if the residual annealing oil is not removed from the bearing surface, the "break-in" period can be eliminated.

MATERIAL SELECTION

Often no clear-cut indication exists regarding the material required for a particular bearing application. There are many situations where all three resins are applicable; and in these instances, the selection becomes one of cost.

Bearings of "zytel" nylon and "delrin" acetal resins can be injection molded and are particularly attractive for mass production assemblies. Bearings of reinforced "teflon" TFE resins are usually more expensive in large quantities and are more often adapted to use on more specialized equipment.

Some bearing applications are clearly suited to the properties of one resin. For example; if low friction, at high load and low speed, is the design requirement "teflon" TFE resin is the most logical first consideration. If abrasion resistance is paramount, "zytel" nylon should be considered first. On the other hand, if maximum resistance to creep is called for, "delrin" acetal or "teflon" TFE fabric is indicated. However, each bearing application must be examined in light of its own specific design requirements in order to select the most suitable material. Adequate end use testing of a properly designed bearing is the final indication of the proper material.

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Discussion

PRESENTED BY

A. E. CICHELLI, Lubrication Engineer, Construction Engineering Dept., Bethlehem Steel Co., Bethlehem, Pa.

G. S. HUDSON, Sales Technologist, Sales Service Laboratory, Polychemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

A. E. Cichelli: As for plastic bearings, the authors are undoubtedly aware that most of the plastic bearings we use are phenolic-resin-bonded laminated fabrics, which, incidentally, when dry, serve as brake materials. Apparently, these new materials, when dry, serve as "anti-brake" materials. This characteristic, therefore, makes them most attractive. Steelmen know what happens when water does not reach the conventional fabric bearing!

However, it appears that these new plastics do not have the load carrying capacity that we are accustomed to, although we understand oriented fibers are introduced into them to improve this property. Certainly, we hope that they will compete with some of the older materials. We have many high-speed process units served by small bearings that might lend themselves to their use, primarily because of the difficulty of supplying proper lubrication under certain conditions.

We have had under test in one of our plants a plastic material for spindle slippers in a cold strip skin pass mill. Their cost was about three times the price of the original brasses they replaced, and their life was about ten times, and so we are highly encouraged. We believe this is a real potential for this type of material.

At the end you mentioned 0.6 in. thickness or less has been used successfully. What is the limit in the other direction? Is this a matter of strength limitations, or economics?

Do you have any examples that you can give us in steel mill or similar services? You illustrated a guide bearing. Did you say that the guide bearing is subject to 3000 psi?

G. S. Hudson: One application, an elevator gib, or guide, undergoes loads up to 3000 psi. These bearings are unlubricated and are limited by the heat that is generated. Since the gib is continually moving against a cold piece of steel, the surface temperature does not get as hot as it would against a rotating steel shaft.

These materials will carry loads higher than those indicated in the paper. But, if this is continued over a prolonged period, the frictional heat will raise the temperature of the bearing surface above the desired limit

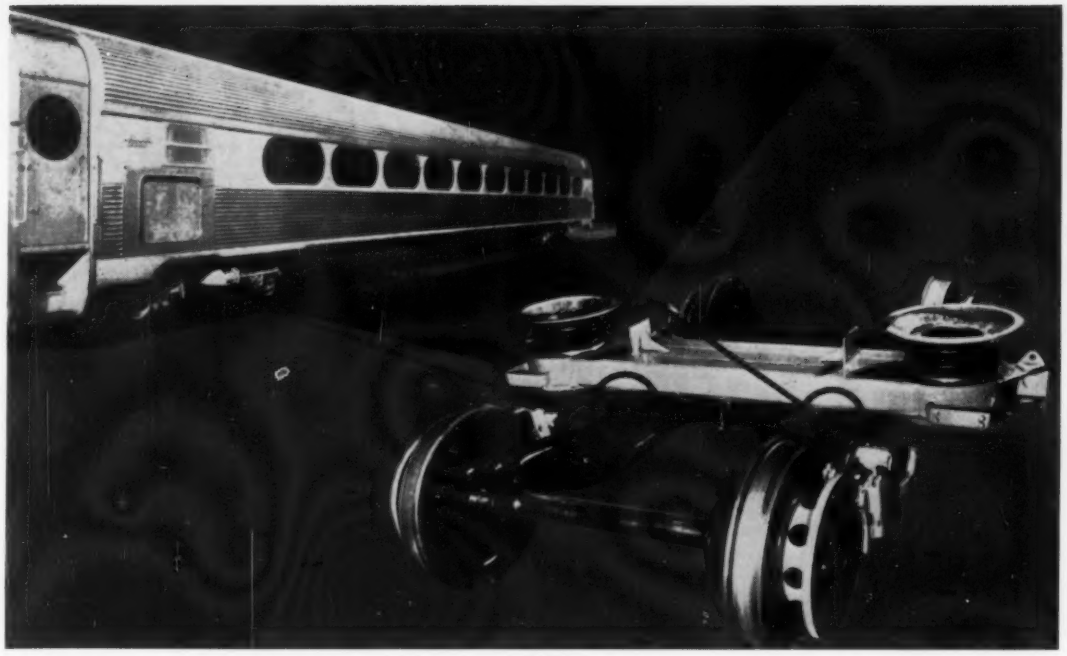

Figure 8 — Bearings of teflon TFE-fluorocarbon resins are used as booster pad bearings on railroad cars to give a bearing which will work without lubrication even in dirty applications.

and excessive wear will begin. If just for intermittent service, the bearing load can approach the strength of the bearing material. However, the design guides which are indicated are for dry, continued service; dry meaning unlubricated. They are not for intermittent service. If lubrication of any kind is added, or if it is intermittent service, so that the heat either is not generated, or has a chance to dissipate into the system, the load and the speed can be increased. This is part of the cautious experimentation mentioned in the paper.

Insofar as current applications in the steel mills are concerned, we are not familiar with any to date. We are sure, however, that there are probably many applications which we could find if we were to go directly into a mill to look at the equipment.

As to thickness, a thin section for a journal bearing is recommended in order to get the maximum heat transfer into the housing and shaft. If you are running an installation which has a good heat sink, you can go up in thickness as far as this heat dissipation rate will allow. This, as yet, has not been reduced to calculable numbers but we hope in the future that it will.

There are bearings that go up to 1½ and 2 in. in thickness. However, they operate at elevated conditions only because the heat is dissipated into the shaft, or some other sink.

A. E. Cichelli: Those values are in steel plant ranges and I am encouraged by the fact that you can use these materials up to those pressures.

However, we would certainly like to have, if possible, more design information for more heavily loaded conditions. ▲

Revised and rearranged collection of articles which appeared in the Iron and Steel Engineer between 1943 and 1950 . . . a book for rolling mill men and for anyone interested in rolling mills and roll design . . . written from a practical viewpoint by one who has had considerable experience in the art of roll design.

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"U-FIRED" SOAKING PITS

by K. E. DINIUS,* Chief Engineer
South Works, United States Steel Corp., South Chicago, Ill.

. . . . the "U-fired pit makes efficient use of blast furnace gas as fuel in the regenerative type pit design . . . .

THE new blooming and structural mill facilities at South Works contain many features which are new and novel in design and application. One such item which has created considerable interest is the soaking pit installation serving the new 53-in. blooming mill. This installation is unique in many respects, including the design of the pits themselves, and the over-all layout and general arrangement of the pits and related facilities. This paper will discuss some of these features and describe the entire pit installation in a general way without reference to technical details.

South Works is one of the oldest plants in the Chicago district with numerous facilities crowded into a very limited area. No vacant space is available in which to make major facility installations without considerable dismantling, moving and rearranging of existing facilities. This dictates maximum ingenuity and imagination in the engineering and layout of any large new facility. These new blooming and structural mills were installed in a very limited area between an existing beam mill and a 28–32-in. structural mill, which would ultimately be replaced by the new mills. However, each of these mills had to be maintained in operation during the construction period. In addition, a 35-in. blooming mill and a 22-in. structural mill were in this area and had to be dismantled to provide sufficient space for the new facilities. Included in this work was the relocation of several substations, with an extensive distribution system handling 22,000, 2200, and 440-volt, 25-cycle power, and 250-volt, d-c power. These restrictions and other nearby facilities such as open hearths, stripper buildings, etc., dictated a layout with the soaking pits at right angles to the new mill delivery table. Because of these extremely restrictive conditions, the old adage—"Necessity is the Mother of Invention"—was literally true in the development and design of the new soaking pit installation.

After establishing the heating capacities required to meet the mill needs in terms of square feet of soaking pit hearth area, number and size of pit holes, it became necessary to design and develop pits which could meet these requirements and be installed in the space available. Numerous modern pit installations were studied and investigated, and many layouts were made before arriving at a satisfactory solution.

The availability of blast furnace gas in large quantities dictated the fuel to be used and also dictated the advisability of regenerative type design in preference to recuperative design more commonly used with higher Btu fuels.

Another feature which was highly desirable, but not mandatory, was the design of the pit building so the pit crane runway could be continuous with the crane runway serving the adjacent 54-in. blooming mill. This would provide maximum flexibility and permit the pits and the two 25-ton pit cranes of the 54-in. blooming mill and the three 25-ton pit cranes of the new 53-in. blooming mill to serve either mill. With these features established, known designs and types of pits were considered, but in all cases difficulties or unsatisfactory features were such as to preclude their use.

It was during this stage of development that the

* Deceased.

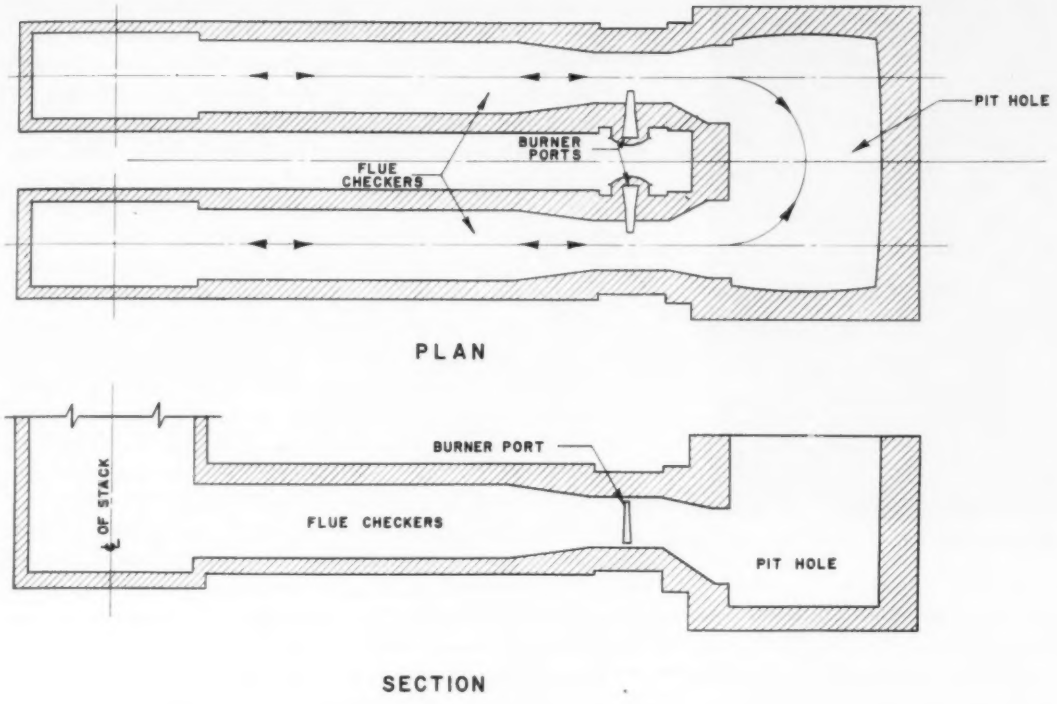


Figure 1 — "U-fired" pit arrangement permits a ratio of pit area to building area which is double the standard regenerative design.

"U-fired" design was conceived and developed by our engineers. The pits are designated as "U-fired" since the flues are on the same side of the pit hole proper and firing is in a horizontal "U." This principle is illustrated in Figure 1. The design incorporates an induced draft stack system which permits completely isolated and metallic clad flues with no chance of short-circuiting combustion air to the stack. It also permits a ratio of pit area to building area about double that of the standard regenerative design and about equal to that of modern recuperative design. Furthermore, this stack system provides individual pit draft control. Excellent circulation is maintained by the change in direction of the gases in the pit proper, and full-off and full-on firing practices. Gas bouyancy in the pit proper is offset by low exhaust ports.

This unusual design was not accepted blindly. It was submitted to the U. S. Steel applied research laboratory in Pittsburgh, who prepared and studied scale models to prove the design. Also, two holes of the 35-in. blooming mill pits, which were still in operation, were revamped to form a working model which was used in actual operating practice until the pits were dismantled.

The laboratory tests were quite satisfactory. Pit circulation was not critical to ingot placement and was exceptionally good on all faces of all ingots. The working model showed equally good results. Heating time with straight blast furnace gas was practically equal to heating time with enriched blast furnace gas. Ingot temperatures as drawn indicated no differences in ingot placement in regard to heating ability. On straight blast furnace gas, cold steel from a stock pile was drawn and rolled in seven hours; steel that was five hours from the open hearth tap to pit charge was drawn and rolled in four hours or less; and steel three hours from open hearth tap averaged slightly less than three hours.

As a result of the outstanding performance of the working model and the findings of the laboratory tests

Figure 2 — General plan of 53-in. blooming mill soaking pit building.

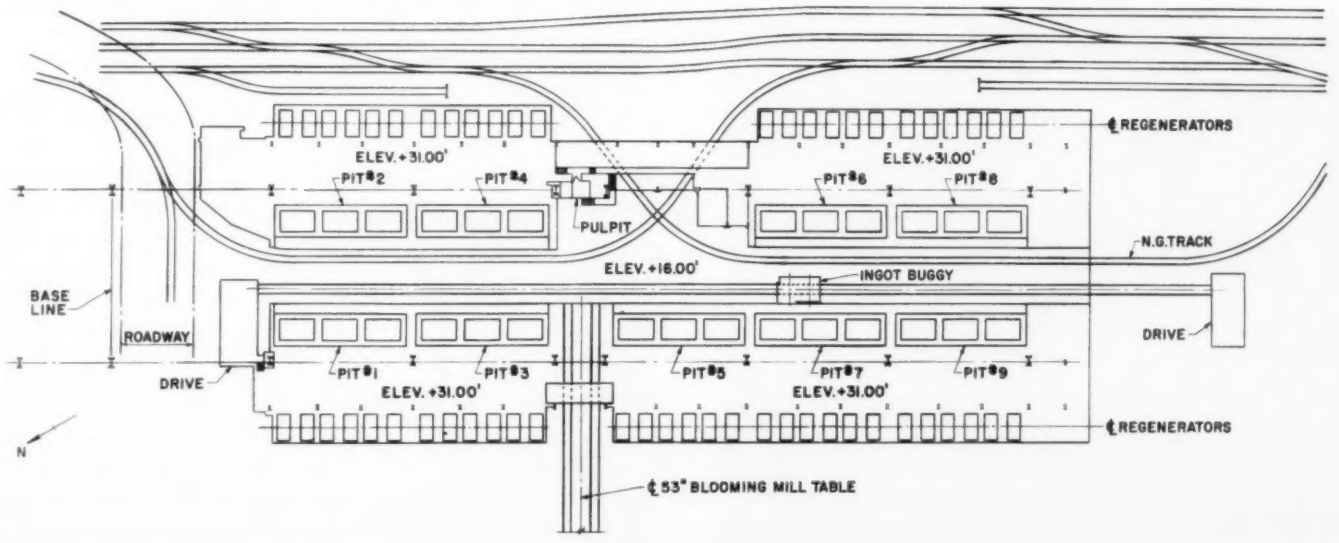


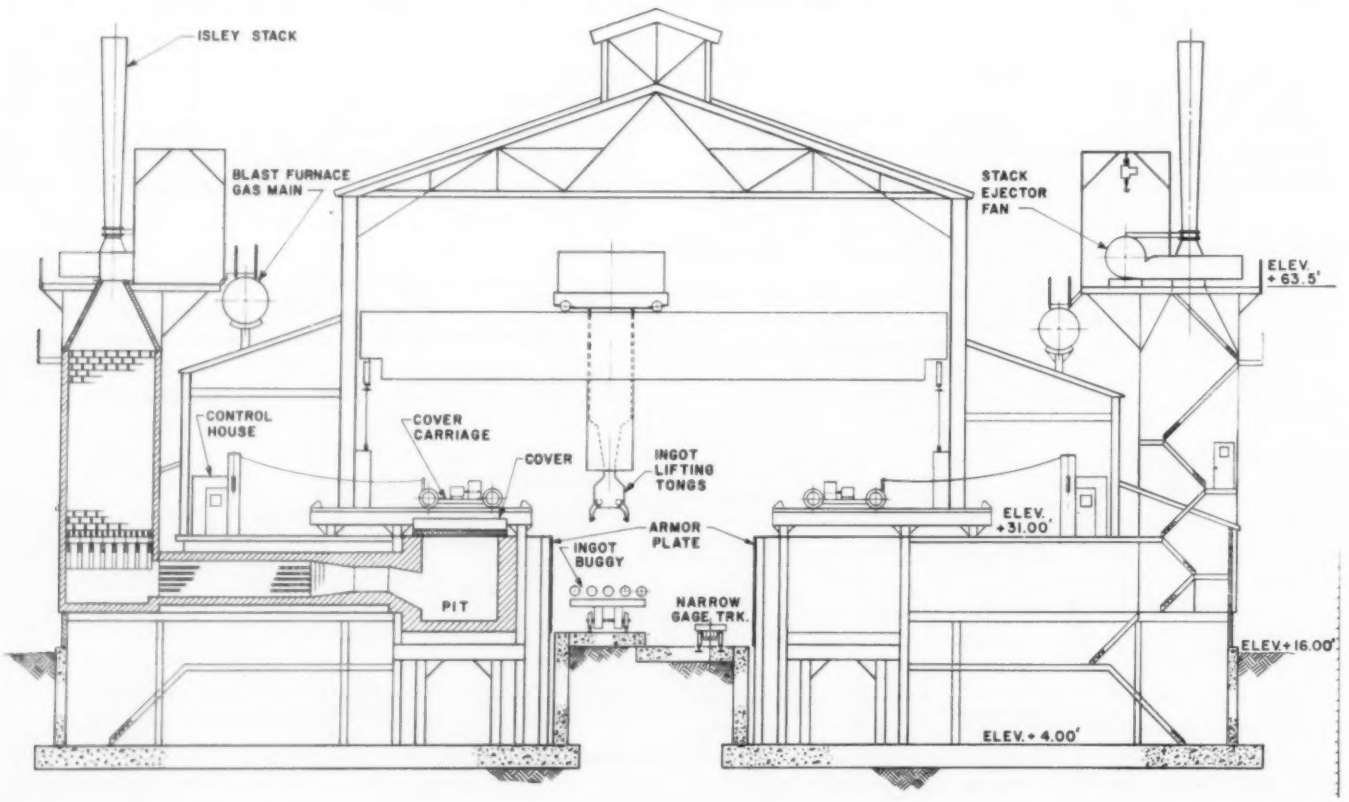
Figure 3 — General arrangement of pits.

with the scale model, it was decided to incorporate the "U-fired" design in the pits for the new 53-in. blooming mill. The general plan of the final arrangement of pits and related facilities as installed for this mill is shown in Figure 2.

The pit installation consists of nine pits of three holes each, with each hole 10 ft x 16 ft-9 in.; giving a total of 4500 sq ft of hearth area. The pits are arranged in two rows on each side of the pit building, with five pits on the mill side of the building and four on the opposite side. With this arrangement, requiring approximately one half the length of conventional installations, all pits are reasonably centered around the mill delivery table, providing minimum travel time and increased ingot handling efficiency. The ingot buggy track and the ingot receiving tracks are between the two rows of pits. The four pits on the side away from the mill are arranged in two groups with a space between the two groups for entrance and exit tracks. This was necessary in order to permit rapid handling of heats coming into the building, since there was only space sufficient for a single ingot receiving track at any pit location. The ingot buggy is a rope-operated table top car permitting ingots to be delivered to the mill with either top or bottom forward without the necessity of a turnaround in the entry table. The entire pit building is only 450 ft long, but connects directly to the crane runway of the adjacent 54 in. mill pit building, which has the same span and elevation. Each pit hole is provided with its own cover operating mechanism, since no space was available for handling and laydown by pit cover cranes. Leantos are provided on each side of the pit building to house the necessary controls and permit the covers to be withdrawn during ingot charging and drawing. This entire arrangement provides efficient handling of ingots with a minimum of crane-bridge travel. The layout and arrangement just described is shown in Figure 3.

The regenerators or checker chambers and the stack system for each pit are located outside and beyond the leantos on each side of the pit building. This arrangement and its relationship to other facilities is shown in Figure 4, which is a section through the pit building. The horizontal flues extend from the pit proper to the checker chamber and stacks outside the building. These are entirely metal clad structures above ground with refractories and insulation to prevent any appreciable loss of heat through radiation. The horizontal flues are provided with some checker brick, but the main checker chamber is contained in the vertical portion leading up

Figure 4 — Cross-section through 53-in. blooming mill soaking pit building.



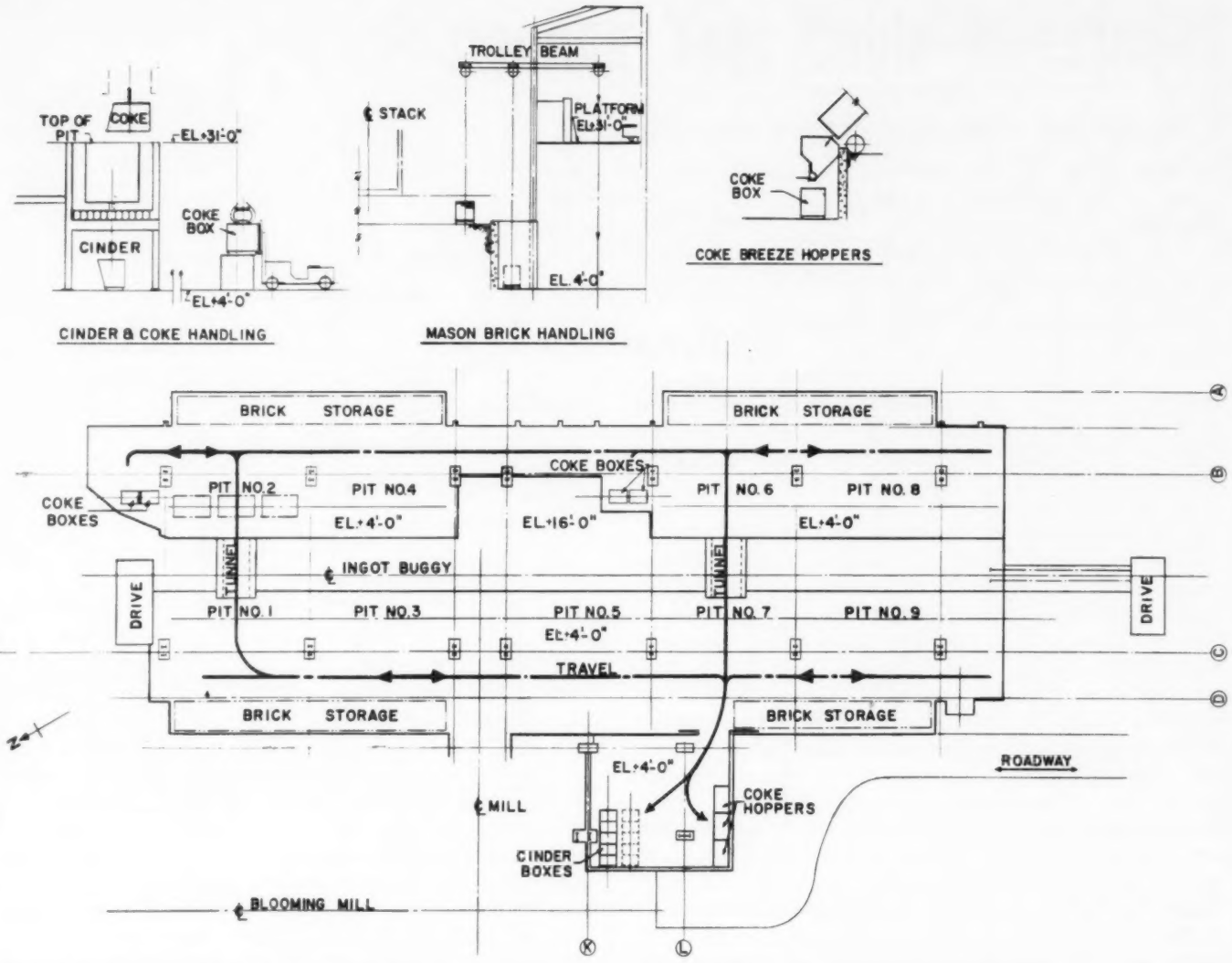


Figure 5 — Basement plan and section shows that arrangement provides efficient material handling.

to the stack. With this type of design the combustion air and draft fans are located on platforms above the checker chamber and at the base of the stack. As can be seen from this section, the design permits adequate basement area for good ventilation and ease in handling pit slag. It also provides space for the storage of brick and spare parts, as well as the handling of coke breeze for the making of pit bottoms. Cinder, cinder boxes, coke boxes, and palletized brick are handled throughout the basement, with lift trucks. This arrangement, shown in Figure 5 provides very efficient handling of these materials and permits good housekeeping conditions throughout the area. This was an important consideration in this installation because of the lack of space for such facilities elsewhere. A typical view of the basement clear area is shown in Figure 6.

With an abundance of blast furnace gas available, the pits have been designed to utilize blast furnace gas alone, although provision is made for enrichment with natural gas if and when it should be necessary. Figure 7 shows a plan and section of the arrangement of the fuel lines for an individual pit hole. Main headers for the blast furnace gas are located on supports above the leanto on each side of the soaking pit building, with small downcomers to each pit. A natural gas header also runs overhead on each side of the pit building, and is arranged with separate lines at each pit for easy control and enrichment as required for individual pit holes. The gas piping with shut-off and control valves and fuel reversing valves are located in the open basement area beneath the horizontal flues, and are readily accessible for maintenance, repair or adjustment. Fuel

Figure 6 — Basement area is clear.

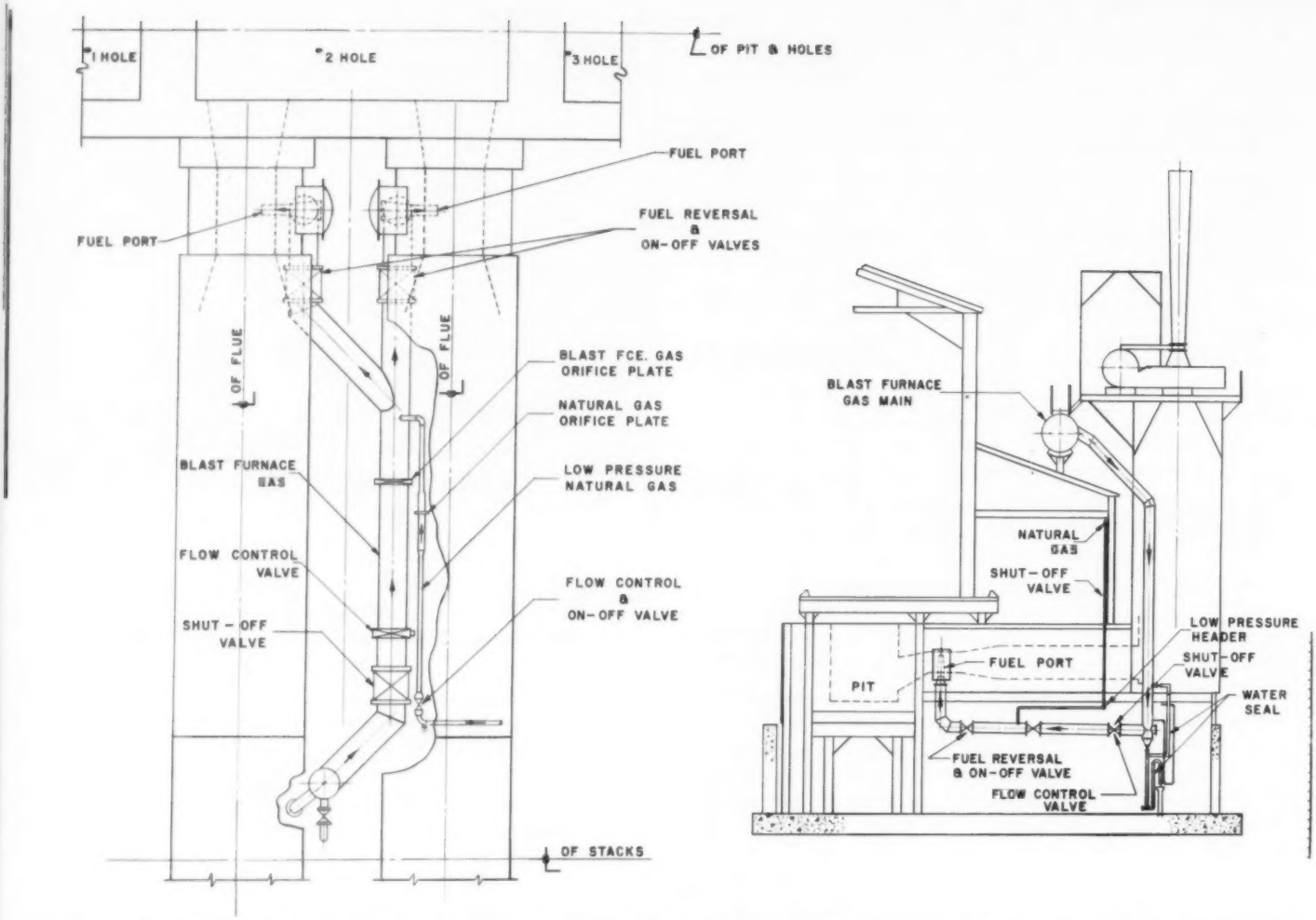


Figure 7 — Pits can use either straight blast furnace gas or blast furnace gas enriched with natural gas when necessary.

ports enter the inlet flue on the side, as indicated on the diagram, and permit good mixing of fuel and combustion air. The stack system provides positive draft and pressure control under all firing conditions. It also permits the use of small valves in place of the customary large water cooled dampers required with the more conventional arrangement of checkers and with natural draft stacks. This flue and stack arrangement also permits ample checker capacity for maximum preheat of combustion air. Full-on and full-off firing practice is used providing relatively simple control and maximum circulation of the gases in the pit proper at all times. Excellent results are obtained in heating cold steel with only blast furnace gas as a fuel. A view inside a pit hole, showing the ports on one side, is shown in Figure 8.

Figure 8 — Gas ports in soaking pit holes.

Another interesting feature of the over-all pit design for this mill is the arrangement of protection armor for the pit sides adjacent to the ingot buggy and ingot receiving track. Since this is a very restricted area and likelihood of damage to the pits is extremely great, an arrangement of heavy plates backed-up by railroad type car springs to absorb shock were installed on the pit faces adjacent to the ingot tracks. This may appear to be "gilding the lily," but past experience under similar conditions on other pit installations indicates that it is more than justified through a reduction in damage to the pits proper.

Some of the pits of this installation have been in service for several months, but under abnormal operating conditions. Reliable performance data are not yet available. Pits of this same design have also been installed at the 44-in. slabbing mill and the 54-in. blooming mill to replace or supplement existing pits. However, performance tests are not complete or conclusive on any of the installations to date. Only minor changes and adjustments have been necessary, and indications are that pit life and performance will equal or better that anticipated in the original designs. ▲

Protecting Your Cable Investment

Practices which will help cable life include selection of proper cable, careful inspection, good storage practice, wire straightening and lubrication for pulling, placing pulling tension on strongest parts, protection of cable from excessive temperature changes, good splices, and care in making bends.

by CHARLES E. VAN HOY,
Assistant Technical Director,
Rubber Product Research and Development Laboratories
Anaconda Wire & Cable Co.,
Marion, Ind.

INDUSTRY in general has always been a large and important consumer of electrical wire and cable. The steel industry in particular has consumed vast quantities of cable during the rapid expansion and modernization which has taken place during the last two decades. The continuing growth and the maintenance of present facilities in the steel industry are expected to require large quantities of wire and cable for many years to come. This means that the industry has made and will continue making very sizable investments in these products, and proper protection of this investment can yield a handsome return. This return will come in the form of increased life for wire and cable and also less downtime in mill operation.

Protection of investment in wire and cable can be accomplished in five areas, namely: planning, procurement, storage, installation and maintenance. It becomes obvious immediately, then, that this will require some attention from a number of people or groups such as management, engineering, purchasing, receiving, installing and maintenance. Obvious also is the fact that these groups must cooperate in order to make the effort a success.

PLANNING

In the planning stage, the old byword "Think Big" is appropriate. Many can recall electrical systems which were installed with insufficient thought given to future requirements. There are a number of such instances which could be cited in the industrial and utility fields. Lack of planning or a distorted sense of economy may lead to electrical systems which quickly become badly overloaded and are hazardous to operate as well as being a fire hazard. Of course such conditions often cause excessive downtime in the mill and this adds unnecessary expense. These "shoestring" installations are unduly expensive to expand or modernize. A properly designed electrical system, planned for reasonable future expansion, will pay repeated dividends by avoiding the need for splicing in circuits in odd and unorthodox fashion. These make-shift circuits, usually called temporary, frequently make real trouble in operations and they are quite expensive to maintain.

The planning stage is the time to see that the right wire or cable is selected to do a particular job in the best possible fashion. Just as one makes certain steels to do certain jobs, we make different wire and cable to give the best performance under given conditions. Do not be misled into thinking that there is one insulation or one construction of cable which can do everything best. The manufacturers must work closely with the user and, by mutual understanding and effort, select or perhaps design the best cable for each particular set of conditions. Economics, variations in environment and electrical requirements may dictate the use of several different cables to accomplish the purpose of a particular circuit. Some applications require cable for stationary use while others require a cable built for portability by being light in weight, flexible and extra resistant to mechanical damage. There are situations where the cable should contain an electrostatic shield while in other cases a nonshielded cable is entirely satisfactory. Choice of conductor size and material must be made carefully in order to obtain the desired electrical characteristics of the circuit. Operating temperature, environment, installation problems and other such matters force a selection of the best type of insulation for a particular application. Location, type of installation, surroundings and possibilities of mechanical damage must be studied in order to select the best covering for the cable. Bear in mind that the best cable will be of balanced design; that is, not just a few but rather all of the pertinent requirements will have been considered. This problem of selecting the right cable may sound a little complex but the importance of this step cannot be exaggerated. In making an investment; be sure you are right. Fortunately there are a number of reliable, reputable suppliers of wire and cable who offer engineering assistance and technical guidance in selecting the best material and the user is urged to make use of this service.

PROCUREMENT

At the procurement stage, the use of known, reputable sources of supply offers definite advantages. The technical services mentioned above are an example. Also it is at this time that the most economical lengths of wire can be determined. Frequently exact lengths can be specified and thereby avoid the cost of unnecessary splices during installation. Quantities and discounts can be arranged and advantage taken of the savings which are possible. More frequently than is usually realized,

the best type of packaging can be selected. Sometimes an open coil or a coil in a carton will serve the installer best; under other conditions, considerable installation time may be saved if the cable is in long lengths on reels. The nonreturnable, disposable type of reel may be available and offer a saving. During procurement, delivery schedules should be discussed and arrangements made for coordination between delivery and use of the cable. To have the cable on hand when it is needed saves construction cost. However delivery long before the material is needed can lead to confusion and sometimes expose the cable to possible damage prior to installation.

STORAGE

When the purchaser receives a shipment of wire or cable, a thorough inspection of the package is advisable. If the carton is broken, the reel damaged, or there are other signs of rough handling, make a careful examination of the contents. Remember that one damaged spot on the cable, regardless how small it may be, can lead to a serious service failure. There seems to be a tendency to handle cable as if it were garden hose or pipe simply because it presents the same general appearance. Frequently cables are damaged in what appears to be a superficial manner; however, the more important damage is internal and not visible. This leads to cable being installed and placed into service where it will operate for a short while and then fail. This makes the failure appear as a fault of the cable, but actually the trouble resulted from earlier mechanical damage. Any damage incurred during shipment needs to be detected immediately so that appropriate action in the form of repair or replacement can be taken before there is urgent need for the wire to be used. Replacement of some complex cables may require six to eight weeks, so early detection of difficulty is essential.

Once it has been determined that the wire and cable arrived in good condition, see that proper warehousing and storage practices are used so that the product can remain in that condition. Storage temperature should be kept within reasonable limits. Low temperatures as such are seldom harmful; however, when combined with moving, impact, flexing and other mechanical actions, definite damage in the form of cracking, flaking or complete rupture of the coverings and insulation can result.

Excessively high temperatures alone can cause general degradation and shorten the service life of cable. After all, some of the materials used in cables are thermoplastic and, therefore, will soften and flow when exposed to elevated temperatures. Rubber and many other materials undergo chemical and physical changes when exposed to high temperatures and their service life is reduced. Storage near heating units, steam pipes, etc., must be avoided. Actually satisfactory storage of wire and cable at temperatures of 10 to 110 F is relatively simple if a little thought is given to the matter.

Crowding of the storage area is a common bad practice. Wire on reels is often rendered unfit for use by letting the flange of one reel crash into the wire on another reel. The possibilities for this happening are shown in Figure 1.

The possibilities of this mechanical impact and crushing can be reduced by using the arrangement shown in Figure 2.

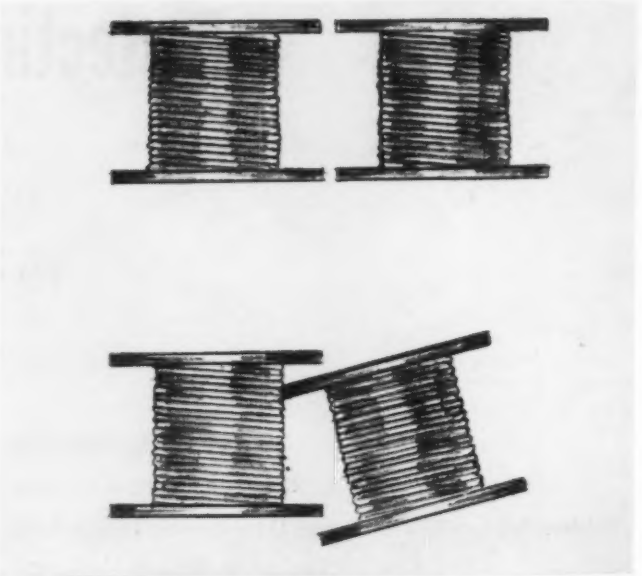


Figure 1 — Possible damage to cable as shown at bottom can occur in attempting to arrange reels flange-to-flange.

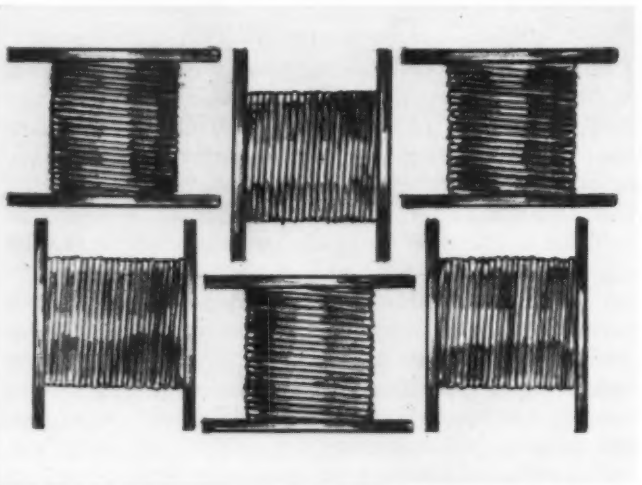


Figure 2 — This arrangement of reels is suggested to prevent damage.

In order to conserve floor space and still protect the cable properly, the arrangement in Figure 3 is suggested. These fixtures are inexpensive and provide an easy, convenient method for handling and storing reels of cable.

Another common bad practice in storage of wire and cable is the failure to rotate the stock. Very few materials improve with age, and the longer an item is stored the greater the chances for damage; therefore, the older material should be used first. This is often neglected, as illustrated by the following letter received recently from one of our sales offices: "This refinery carries large quantities of wire and cables in stock in their warehouse. They have been having quite a number of cable failures and are quite disturbed.

"Some of their trouble is attributed to poor warehousing and handling and nonrotating stocks. Some cables have been in stock as long as four years.

"Is there some sort of test that you could recommend they could perform before the cables are installed? Anything you can recommend will be appreciated."

The practice mentioned in this letter is an illustration of an area where definite improvement can be made in

protecting the cable investment by proper warehousing and rotation of stock.

INSTALLATION

The next step is to see that proper technique and adequate care is used when wire and cable is being installed. There are a number of simple rules which are worth mentioning just as reminders. For example, conduit, pipe and fittings should be free of burrs and sharp protrusions. One contractor pointed proudly to his use of metal bushings to guide the wire into conduit. He failed to note, however, that continued use had worn grooves in the bushings and left very sharp ridges which cut the insulation on the wire. Plastic bushings would be a better choice. Also, conduit, pipe and ducts should be free of nails, glass and other such matter before the wire is pulled in. A swab pulled through ahead of the wire will often reveal a surprising amount of variety of debris which could cause severe damage when the wire is pulled through. So far as is practical, conduit and pipe runs should be as straight and as short as possible. Of course a reasonable degree of straightening and the application of an accepted pulling compound not only facilitates installation, but also reduces the mechanical stresses on the wire since less force is required for pulling. Believe it or not, there are those who hammer a cable in order to straighten a kink. Also, we have seen a heavy timber used to pry a large cable into position. These practices make real trouble.

Direct burial of cable in the soil has become a popular type of installation. However, it is feared that the word "direct" has been interpreted too literally. It was never intended that cable should be buried in whatever might be found in the earth. Trenches should be cleaned by the removal of rocks, glass, etc.; for freezing and thawing causes such objects to shift position and possibly exert destructive forces on the buried cable. Sand, of course, is the material recommended as the bedding and immediate covering for the cable. Situations where wires cross over or rest on each other should be avoided. Also a treated timber or some other material to prevent someone from digging into the cable at a later date is a cheap form of insurance for your cable.

When wire or cable is being pulled-in, it is important that the pulling tension be applied to the strongest component. Ordinary single-conductor material should have the pulling tension applied to the bare conductor. Tension applied to the covering materials tends to stretch them and can lead to actual breaks in some cases. Preassembled aerial cables should be pulled by the messenger, not by the insulated conductors. An interlocked armor cable should never be installed by pulling on the armor since this may cause severe damage by unlocking the armor.

Figure 3 — Suggested method for stacking reels saves space.

The remarks offered earlier concerning the detrimental effects of high temperature on wire and cable are applicable to installed cable also. A few simple precautions can do much to extend the life of the cable and insure trouble-free service.

The use of adequate ventilation in ducts and tunnels will certainly assist in keeping operating temperatures near normal. Where wire and cable must function in close proximity to extreme heat, baffles and heat reflectors can afford protection and extend cable life. Such conditions are encountered frequently in industries where cable may be near furnaces, ovens, steam pipes and other high temperature apparatus. By selecting the proper cable and using baffles or other physical protection, cable can give excellent service in some surprisingly hot locations.

Splices and terminations must be as near perfect as possible. Records will show that lost time and interruptions of service are due more to poor splices and terminations than to the cable itself. Here, the old adage "A chain is as strong as its weakest link" is extremely apropos. Just keep in mind what is expected of the cable and one automatically has the requirements for splices and terminations. It is interesting, but distressing, to note that proof-testing of installed cable is often rather difficult because splices and terminations fail so badly. Another bad weakness of these joints is that frequently they permit the entrance of water into the cable and this results in some very troublesome problems.

Perhaps the greatest single mistreatment given to wire and cable during installation is that of bending too sharply. This sharp bending can cause immediate destruction of some cable components while other effects are of an insidious nature and the harm will be felt long after the cable has been energized. A shielded high voltage cable serves as a good example and we can refer to Figure 4 which is a cut-back view of a modern rubber-insulated high voltage cable.

It is to be noted that the conductor is stranded so that it can be bent with reasonable ease. This stranded conductor is comprised of a number of spirally wound wires made of metal, a relatively inelastic material, the conductor bends easily only because the individual wires adjust themselves to a new position. This rearrangement causes stresses as shown in Figure 5.

Since the conductor bends approximately on a centerline through its length, there is an elongation of the outer surface of the conductor and a contraction of the inner surface. Two marking lines, placed around the conductor before bending, would shift to the position shown in the side view of the bent section, after bending. This means that any rubber insulation surrounding this conductor would be stretched at the outer surface and compressed at the inner surface. In addition to these stresses, it can be shown that there is a shearing stress and also the insulation is stressed across the longitudinal axis.

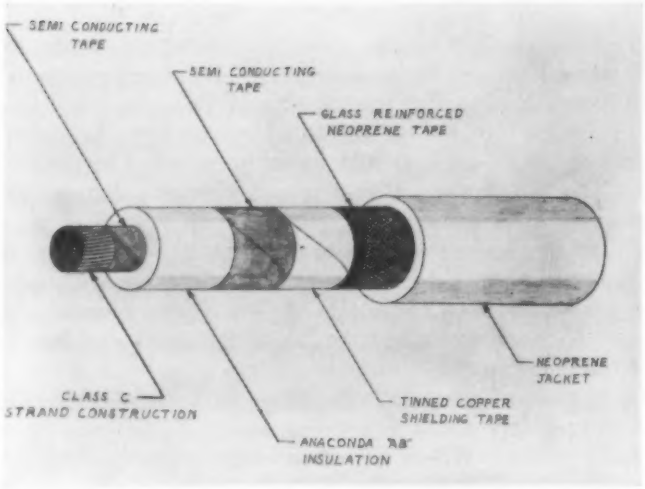


Figure 4 — Constructional details of modern high-voltage rubber-insulated cable.

These mechanical stresses on rubber are detrimental in two ways. First, stressing causes the rubber to age more rapidly; this means loss of tensile and elongation and perhaps the development of cracks. Second, stressed rubber is more subject to attack by ozone; and again, this can cause cracks and lead to electrical failure.

In addition, sharp bends can cause serious disruption of the carefully planned shielding system used on high voltage cables. The semi-conducting tape which covers the strand and the insulation can be fractured and rendered useless at the points of rupture. The metallic shielding tape may become badly wrinkled or unlapped and thus be ineffective at these points. Thus these carefully planned safeguards are destroyed and ozone can be produced in the worst possible spot, where the rubber has been stressed. Therefore, excessively sharp bending of wire and cable should be avoided in order to protect your investment. It is suggested that the latest proposed recommendations of the Insulated Power Cable Engineers Association be followed carefully and never be violated. These latest proposals are given in Table I.

TABLE I
Power Cables Without Metallic Shielding or Armor

The minimum recommended bending radii as multiples of the over-all cable diameter given in the following tabulation are for both single and multiconductor cable with or without lead sheath and without metallic shielding or armor.

Thickness of conductor insulation, in.	Over-all diameter of cable, in.		
	1.00 and less	1.01 to 2.00	2.01 and over
	Minimum bending radius— as multiple of cable diameter		
10/64 and less	4	5	6
11/64 to 20/64	5	6	7
21/64 and over	..	7	8

Power Cables with Metallic Shielding or Armor

a. **Interlocked armored cables**
The minimum bending radius recommended for all interlocked armored cables is seven times the over-all diameter of the cable, except as noted for shielded cables.

b. **Flat tape and wire armored cables**
The minimum bending radius recommended for all flat tape armored and all wired armored cables is 12 times the over-all diameter of cable.

c. **Shielded cables**
For all cables having metallic shielding tapes the minimum recommended bending radius is 12 times the over-all diameter of the completed cable.
For all cables having wire shielding, the minimum recommended bending radius is the same as given in the table under power cables without metallic shielding or armor.

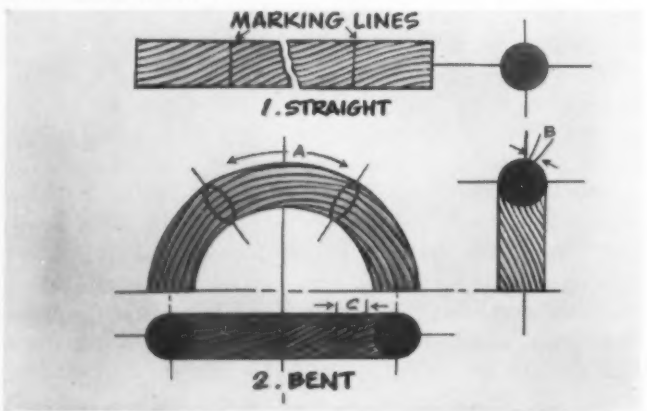
MAINTENANCE

Proper maintenance of wire and cable is a vital link in the chain to protect cable investment. It is important to determine what caused a cable to fail and assistance in this matter is available from reputable cable manufacturers. Only by knowing what caused the failure can proper remedial action be taken.

Repairs and splices must be made with the best materials and the best workmanship. These sections of the circuit are expected to perform the same as the remainder of the circuit.

By all means, be sure that accurate records are kept. These records should include date of installation, supplier of cable and name of installer. When failure occurs, a record should be made to show the cause of failure and the corrective action taken. These records provide a means of calling attention to troublesome installations or materials and they serve as a basis for proper corrective action. Such records are kept on machines and other equipment and wire and cable deserves similar attention. Here is an opportunity to know what troubles are and what should be done about them.

Figure 5 — Illustration shows stresses which takes place when cable is bent.



SUMMARY

In summary then, one can protect investment in wire and cable by doing the following:

1. Plan each job carefully and allow for the future.
2. Use reputable sources of supply and make use of their services.
3. Select the proper cable for each situation.
4. Inspect material carefully when received.
5. Use good storage practices and rotate your stock.
6. Conduit, pipe, fittings, etc., should be smooth and free of debris.
7. Straighten the wire and lubricate while pulling.
8. Place pulling tension on the strongest part.
9. Protect the cable from excessive heat and cold.
10. Make high quality splices and terminations.
11. Do not bend cable too sharply.
12. Keep complete records of purchases, installations, repairs and difficulties. ▲

The iron powder plant at Alan Wood is the first production application of the H-iron process in the steel industry . . . . initial results indicate that the process may be promising for future expansion of steelmaking capacity.

The Iron Powder Plant At Alan Wood Steel Co.

THE PLANT

by JOHN W. TRAUB,
Mechanical Engineer,
Alan Wood Steel Co.,
Conshohocken, Pa.

THE 50-ton per day iron powder plant at Alan Wood Steel Co. is a step toward a planned product diversification. It is related to a steel company only insofar as it utilizes raw materials and services available. The end products, except for one, are specifically for the powder metallurgy industry. The one exception is the production of briquetted powder for use as melting stock. Provisions have been made so that other elements such as carbon can be mixed with the powders being pressed, if pure iron is not desired.

Alan Wood Steel Co. has been working on and experimenting in the production of iron powder since 1950. Many methods of reducing iron oxide by carbon and hydrogen were studied and after several years a high temperature reduction method was developed which looked very promising and produced high-quality iron powder. Patent rights were secured for the process and a one ton a day pilot plant was put into operation in 1955.

Based on the excellent results with the powders produced, money was appropriated in 1956 for a plant to produce 25 tons of iron powder per day. Just as engineering work was started, the company learned of the fluid bed "H-iron" process. Supposedly this method produced metallic iron at a cost sufficiently low to warrant its consideration as a scrap substitute, so work on the original plant was suspended while an investigation was conducted. After full consideration, it was decided to proceed with an iron powder plant on the basis of the direct reduction, or fluid bed process. Money was appropriated for this plant in December, 1957.

PLANT SITE

Although all of the preliminary experimental and pilot plant work had been performed at our iron ore mine near Dover, N. J., it was decided that with the direct reduction process, it would be more suitable to locate the new plant adjacent to the steel works at Conshohocken, Pa. Reasons for this decision were based on available land for the plant site, availability of services and raw materials and proximity of the open hearth shop as a user of briquettes. Most important of the raw materials is our coke oven gas which is being used in the manufacture of hydrogen. Also, consideration was given to the proximity of existing facilities whose services could be beneficial (machine shop, oxygen plant, railroad, water, etc.)

Because the primary function of Alan Wood is steelmaking, the first plant site selected was outside the area considered to be in reserve for expansion in steel production. The first site was on land that had just recently been rezoned from "heavy industry" to

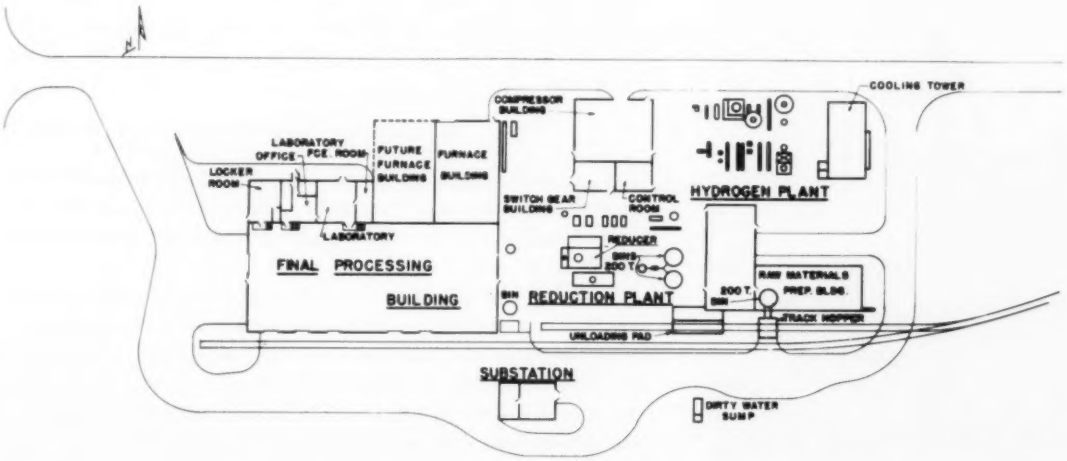


Figure 1 — General arrangement of iron powder plant.

Figure 2 — Plant is laid out so that it is capable of expansion.

"light industry" and, with the wording used in the township zoning ordinance, an iron powder plant was classed as heavy industry. Our appeal to have the area reclassified was contested by various home owners and civic associations in the vicinity, and was finally turned down by the zoning board of adjustment. Although we were quite confident that a court ruling would reverse this decision, it was decided to select a new site, since court action would have meant an additional four to six months delay.

PLANT ARRANGEMENT

Briefly, the iron powder plant (Figure 1) consists of the raw material preparation building, the hydrogen plant, the reduction plant, a cooling tower, the compressor and control building and the final processing building. Flow of material is such that it enters the plant at one end as a raw material and leaves the opposite end as a finished product.

The contractor contracted to design, furnish and erect the hydrogen plant, reduction plant, compressor building and cooling tower (Figure 2). By close coordination with them, an arrangement was evolved to provide a plant that was compact, yet still capable of being expanded. Actually, expansion involves only the hydrogen and reduction sections, because with the low material flow rates, the smallest manufacturing and transporting equipment is more than adequate for handling a day's production from the reduction vessel in an 8-hr shift. Twenty-four hour, seven day a week operation is maintained only in the hydrogen and reduction sections and the roller hearth furnace. All other processing is on a 5-day, 8-hr schedule.

The plant operating and supervisory force consists of a superintendent, four foreman, and 31 operators and workmen. Except for minor work, repairs and maintenance services are provided for by the central mechanical and electrical departments of the steel works division.

Figure 3 — Raw material preparation building.

RAW MATERIAL PREPARATION

Raw materials are delivered to the plant by either truck or rail to a track hopper from where it is transferred by a bucket elevator to a 200-ton storage bin. This bin stands within the confines of the raw material preparation building and extends through the roof.

Briefly, the major preparation process equipment includes a rotary, direct-fired dryer, a water-sprayed rotary cooler, a 1-in. mesh scalping screen, a belt-type magnetic separator, a demagnetizing coil, a ball mill and the final scalping screen. After the material is processed through the equipment it is then pneumatically conveyed to a 200-ton storage bin in the reduction plant.

With economy in mind, this equipment was arranged so as to provide a minimum size building. Another factor that determined the final building design was that the dryer and cooler could have been installed outdoors. This was not done, however, because of fuel economy and general working conditions (Figure 3). The building consists of two sections, one totally enclosed and heated, the other which is the enclosure for the dryer and cooler is open for a height of 10 ft from the ground. The enclosed section is 30 ft wide by 70 ft long with a clear height of 28 ft. It is a structural steel building, uninsulated, with protected metal roof and siding down to a block wall which is approximately 10 ft high.

The other section which adjoins the side of the closed section to form an "L"-shaped building, is also 30 ft wide by 70 ft long with a clear height of 20 ft. Construction is the same except that the block wall has been omitted and there is no heat or concrete floor.

So that we could profit by the contractor's experience and know-how, drawings were prepared showing only over-all building dimensions and equipment foundations, and these drawings, along with a complete specification, were the basis used for obtaining bids on a building that was not to be strictly mill type. This method gave the bidders a chance to include some of their own design, techniques and money saving ideas which reflected advantageously in the cost to Alan Wood.

HYDROGEN AND REDUCTION PLANTS

Unlike the appearance of the steel works, but inherent in the construction for such operations, the hydrogen and reduction plants for the most part are outdoor installations.

The hydrogen plant which utilizes the partial oxidation of coke oven gas for manufacturing hydrogen, occupies only a small area with the generator, scrubber, heat exchangers and piping all being supported or hung on structural steel towers. All the pumps and accessory equipment are also installed outdoors.

The compressor building which is common to both the hydrogen and reduction sections has a 50 by 40-ft section of steel construction which houses the gas compressors, instrument air compressor, nitrogen compressor, freon unit and miscellaneous heat exchangers. A 20-ft wide concrete block extension along the 50-ft width contains two separate rooms. One of these is the control room, and the other, the switchgear and motor control center.

The reducing unit of the reduction plant is a self supporting vessel 5 ft–6 in. in diameter and about 94 ft high with a structural tower around it for access and servicing. This structure extends another 40 ft above the reducer for removal of internals, making the over-all height about 134 ft.

Other equipment in the reduction section consists of two 200-ton storage bins, bucket elevator, pressure hoppers, gas heating furnace and other storage vessels. As with the hydrogen section, a maze of piping is very prominent. Not only are the gases involved, but all of the solids movements are performed in pipes using mostly the dense phase transfer method.

The pneumatic conveyor was designed for taking material from either of two points to either of the 200-ton storage bins. Normally, during the day shift, it transports material from the ball mill in the raw material preparation. During the second and third shifts, the dry ore received from our mine is unloaded. With this arrangement, a 5-day, 24 hr unloading schedule is maintained.

As part of our research program, a 6-in. experimental reducer which has been installed on the reduction vessel tower will enable us to carry out experiments on other materials.

FINAL PROCESSING

After the iron has passed through the reduction plant, it is transferred in either of two streams to the final processing building where it is further conditioned and packaged for shipment. Equipment for this final work includes a furnace, crushers and grinders, conveyors, elevators, briquetting presses, screens, blender and bagging equipment.

Here, as with the raw material preparation building, the equipment was arranged and designed for minimum space requirements. The topography of the plant site was also considered and a three-level plant was utilized, thus minimizing grading. The offices, laboratory and locker room, and furnace building are on the upper level which is 5 ft higher than the main building floor. This added 5 ft in height was also very useful in the design of the furnace discharge. The lower level of the plant provides proper height for shipping by rail and truck.

The main portion of the building is 70 ft wide by 160 ft long with a clear height of 36 ft. This structure was designed for future installation of a 10-ton crane, with runway girders designed but not installed. The cost of the additional steel to do this was very small considering the future flexibility that is available. In the study for a furnace design, we again stressed minimum floor area, and rather than have a straight-through furnace with a return conveyor, the furnace was designed in a U-shape so that the cooling section returns the material to a point beside the charging end. For this reason a building leg at right angles to the main building was used. This section is 40 x 70 ft with a clear height of only 15 ft. It is also arranged so that future furnaces may be installed by a building extension running parallel to this leg.

The main and furnace buildings have protected metal roofing and siding with 1½ in. of insulation. The lower portion of the walls are concrete block, the same as in the raw material building. Generally, these two sections have two truck doors, five railroad doors, a continuous ventilator in the main building, four power ventilators in the furnace section and no windows.

A concrete block leanto along the main building houses the offices, locker room and laboratory. The locker room has facilities for 48 men. The office area includes a washroom and covers approximately 750 sq ft. The laboratory with its furnace room is about 1050 sq ft. Both of these, except for the laboratory furnace room are air-conditioned.

In the purchase of this building, a specification with nine 8½ x 11-in. sketches was all that was used. Again this was done so that the contractors could engineer into it many cost-saving ideas. The specifications were made tight enough to make sure that Alan Wood was getting an acceptable building which met all design codes, but yet, loose enough to allow economical contractor designs. For the use intended, a mill building which is typical of steel plants was not deemed to be necessary.

SERVICES

Coke gas—Because natural gas was made available to our company, it was necessary to extend the coke oven gas supply line to a point on the main ahead of any mill take-offs. Originally, it was planned to tap in at the open hearth which required 1300 ft of piping, but with this change, the line size was increased from 10 to 12 in. and the length became 4000 ft. A special check valve has been installed in the line to the mills to insure that no natural gas passes to the iron powder plant. This is necessary because the hydrogen plant is designed on the basis of using coke oven gas only. Total coke oven gas used is approximately 2,400,000 standard cu ft per day.

Operation of the hydrogen plant is very critical and even an instant's loss of coke oven gas could force a shutdown of 8 to 12 hours. Faced with this problem and the problem of low coke oven gas production due to the low coking rates experienced at times, a sequence was established to cut off coke oven gas users based on uses, production and means of utilizing another fuel. The iron powder plant is second on the priority list with the strip mill annealing furnaces as the only process considered more important. Even then, with an advance notice the annealing section will cut back to keep the hydrogen plant running as long as possible.

Oxygen and nitrogen—These gases are furnished by a nearby producer whose plant's property line is only about 120 ft from the hydrogen plant. Approximately 14 tons of 98 per cent purity oxygen at approximately 500 psig is used per day in the partial oxidation process. For purging, blanketing and as a transferring medium, seven tons per day of nitrogen at 90 psig are used.

Steam—Requirements for the process and heating

are about 10,000 lb per hr. A 6-in. supply line about 1400 ft long connects the iron powder plant to the main at the open hearth and provides steam at a pressure of 100 psig. High pressure steam required for the hydrogen manufacturing process is obtained by vaporizing condensate collected from various points.

Water—Because of the continually increasing demand on the steel plant's water system, a 2700-gpm cooling tower was installed to provide recirculated cooling water. A 6-in., 1900-ft long asbestos-cement pipeline supplies 100 gpm of clarified water for make-up.

A connection with Philadelphia Suburban Water Co. provides the necessary potable water for drinking and sanitary facilities and 10 gpm for miscellaneous process cooling. There is also a 6-in. connection for fire protection which includes two outside hydrants, and a sprinkler system in the laboratory-office building.

Sewers—A 1700-ft long sanitary sewer line connects the iron powder plant to the local borough sewer main which crosses the Alan Wood property. This new line, which is the second metered connection to the sewer main, was sized to handle sewage from future mills. The diversion of the future mill sanitary sewage, which shall come about on the next expansion program, will cost much less since the additional capacity has been provided.

A storm water sewer which parallels the sanitary sewer was installed in the same trench and carries the surface water to a nearby creek.

In the drying of raw materials, the fine dust that is carried in the exhaust gases is knocked out by a wet-type dust collector. This dirty water, together with the water carrying traces of carbon from the hydrogen plant, are collected in a settling sump. After most of the heavy material has settled out, it is pumped to the open hearth slag dump and allowed to filter through the bank.

Compressed air—The iron powder plant, being so remote from the steel plant's air supply, has been provided with two 200-cfm air compressors for general plant use. In addition a 56-cfm air compressor provides for the instrumentation of the hydrogen and reduction sections.

Electrical—The iron powder plant has the advantage of being tied into the steel plant system at a point where it can be fed from either of two sources. Normally, power comes from the 6900-volt cold strip mill feeder, with the alternate source being the hot strip mill line.

On the south side of the plant site, a 24 x 24-ft concrete block switchgear building was centrally located with respect to distribution of the 480 and 2300-volt services. A 1500-kva, 6900/2300-volt transformer and a 2000-kva, 6900/480 volt transformer are located on a pad adjacent to the switchgear building.

THE PROCESS

by K. W. BRULAND, Superintendent,
Iron Powder Plant,
Alan Wood Steel Co.,
Conshohocken, Pa.

FOR many years iron powder has been produced commercially for the powder metallurgy industry by direct reduction of iron oxides by carbon and/or hydrogen below the melting point of iron. To obtain reduction cycles that are not prohibitively long, these processes are operated at temperatures close to 2000 F. Several years ago the Alan Wood Steel Co. initiated a program to study various methods for the direct reduction of finely ground iron ore in this temperature range. Fluidized reduction methods were not examined during the initial studies since results obtained by others were not particularly encouraging. Here, too, indications were that high rates of reduction could be obtained only at temperatures over 1500 F. Unfortunately, at these temperatures, the reduced iron particles stick together and to the container or vessel resulting in serious operating difficulties.

In spite of the many failures experienced by other investigators with fluidization, a new fluidized reduction method was conceived based on technological developments in the petroleum industry. Experience obtained from the operation of a plant at Brownsville, Tex., to produce 20 tons per day of an iron powder catalyst for a synthetic gasoline plant outlined the basic principles for the direct reduction of iron ore fines. A process to efficiently and economically produce metallic iron at a temperature low enough to avoid the usual sticking problem was developed by Hydrocarbon Research Inc. in conjunction with the Bethlehem Steel Corp. and became known as the H-iron process. Iron oxide is reduced in a fluid bed with hydrogen at a temperature less than 1000 F and at a pressure approximating 500 psi. The high operating pressure which is the principal departure from other fluidized processes permits obtaining a high rate of reduction at low temperatures.

Attracted by its potential, the Alan Wood Steel Co. investigated the practicability of using the H-iron process for the production of iron powder. Although it was determined that the process had definite advantages over previously investigated methods, the H-iron product was not suitable for powder metallurgical purposes. At Alan Wood, additional processing methods were developed for treating the H-iron to produce the desired end-products. As a result of the successful developments, the Alan Wood management authorized the construction of a plant to produce 50 tons per day of iron powders.

The Alan Wood iron powder plant is comprised of four interrelated sections as shown by the block diagram in Figure 1.

1. Iron ores are prepared for reduction in the raw materials preparation section.
2. Hydrogen, the reducing agent, is processed from coke oven gas and oxygen in the hydrogen production unit.
3. The ore and hydrogen are chemically reacted in the H-iron reduction section to produce metallic iron.
4. In the finishing plant, the final iron powders are further processed for ultimate consumption by the powder metallurgy industry.

The reduction section alone performs a singular job; namely, removes oxygen from the ore to produce metallic iron. Unlike the blast-furnace the reducer does not eliminate gangue or waste material from the original charged ore. Therefore, to produce powder metallurgical grade iron powder, the ore must be free, or nearly so, of materials other than iron oxide.

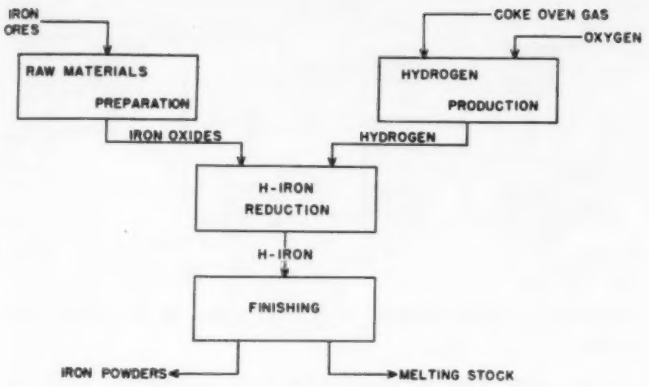
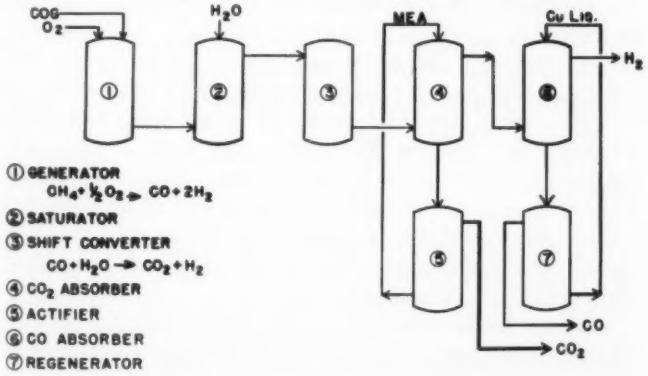


Figure 1 — Iron powder plant is made up of four interrelated sections.

The preparation of raw materials is performed in two widely separated plants. At the Scrub Oaks mine in northern New Jersey, magnetite has been mined and beneficiated by Alan Wood since 1929. The ore containing about 28 per cent iron is crushed and screened to pass a 10-mesh screen. Water is then added to the ore to form a slurry and passed through drum type magnetic separators to remove free gangue. Additional upgrading of the magnetic product from the separators is accomplished on gravity type separators. The final concentrate of 93 per cent purity containing over 67 per cent iron is shipped principally to the company's blast furnaces at Conshohocken, Pa. The ore is uniquely suited as a basic raw material for the H-iron process because of its purity and fine particle size which is essential for fluidizing. Recently, additional equipment was installed at the mine to specifically prepare charge ore for the new iron powder plant. A slip stream from the main concentrate circuit is passed through additional separators to produce "high grade concentrate" of 99 per cent purity minimum. The material is dried in a rotary dryer, loaded in covered hopper cars, shipped to the iron powder plant at Conshohocken and transferred to storage to await further processing.

Additional equipment has been installed at the Conshohocken plant for the preparation of other ores and for the retreatment of the high grade concentrate if deemed necessary. Materials can be received by rail or truck, dried in a rotary drier, magnetically separated to remove waste material and ground to a predetermined particle size in a ball mill operated in closed circuit with a classifying system. The product from this section also is delivered to storage to await further processing.

Figure 2 — Schematic shows production of hydrogen.



Hydrogen, for the subsequent reduction of the iron oxides, is produced by the partial oxidation process. The versatility of the process allows for the production of hydrogen in large quantities at low cost from most common fuels. At Alan Wood, coke oven gas, a by-product from the company's coking operation, is reacted with oxygen in a fuel-rich mixture under pressure, to produce a raw gas which is subsequently subjected to a water shift reaction and final scrubbing. The oxygen for the reaction is obtained from an adjacent low temperature air separation plant which also supplies oxygen to the company's steelmaking operations.

Figure 2 is the flow diagram for the hydrogen production unit. The coke oven gas is received at 3 psi, compressed to about 500 psi by a four-stage compressor and delivered to the partial oxidation generator (1) along with 500-psi, 98 per cent oxygen. Only sufficient oxygen is supplied to burn the hydrocarbon components of the gas to hydrogen and carbon monoxide as indicated by the first reaction shown on the diagram. If complete combustion were permitted, the ultimate products would be water and carbon dioxide. The reaction is controlled primarily by maintaining the optimum reaction temperature and minimum quantities of hydrocarbons and carbon dioxide in the product gas. The latter is determined automatically by an instrument functioning on infrared principles. The carefully controlled reaction produces the desired products of hydrogen and carbon monoxide which is shifted to additional hydrogen in the shift converter.

Prior to the shift conversion the generator effluent gas containing about 68 per cent H_2 and 26 per cent CO (dry basis) passes into the bottom of a saturator tower (2) where countercurrent streams of water saturate the gas with water vapor. The overhead gas leaves the top of the tower and is delivered to the shift converter through a heater for preheating to the reaction temperature necessary for the conversion.

In the shift converter (3) the gas mixture passes downflow through a catalyst, reacting the carbon monoxide and water vapor in a water-gas shift reaction to carbon dioxide and hydrogen as shown by the second reaction. The ratio of water to carbon monoxide, temperature and pressure are controlled to obtain the optimum conversion. The effluent from the converter contains about 75 per cent H_2, 20 per cent CO_2, 2 per cent CO and 3 per cent N_2 (dry basis.)

The hydrogen must be nearly free of carbon oxides in order to minimize the subsequent synthesis of methane in the ore reduction vessel by the catalytic action of the reduced iron.

The carbon dioxide is removed first from the hydrogen gas by absorption in aqueous monoethanolamine (MEA). The product gas emerging from the shift converter is cooled and delivered to the bottom of the CO_2 absorber (4). Rising through the tower countercurrent to a descending stream of MEA, it gives up essentially all of its carbon dioxide and any hydrogen sulphide that might have been present.

The MEA solution containing the absorbed carbon dioxide leaves the bottom of the absorber and is delivered to the top of the MEA actifier tower (5). As the solution descends through a bed of raschig rings, the carbon dioxide is stripped free by ascending steam from a reboiler section at the base of the tower. The MEA

leaves the actifier free of CO_2, is cooled against cooling water and pumped to the top of the CO_2 absorber completing its circuit. The CO_2 leaving the top of the actifier is used for purging purposes in the reduction section of the plant.

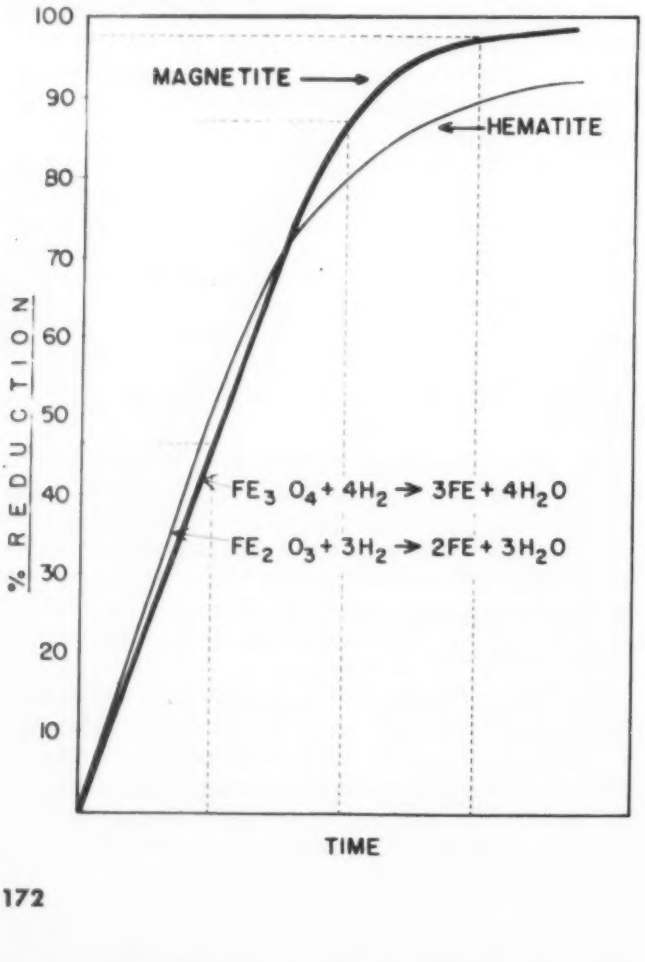
Similarly, carbon monoxide is removed from the product gas. Leaving the top of the CO_2 absorber, the gas with less than 0.1 per cent carbon dioxide is compressed to approximately 700 psi, cooled and delivered to the bottom of the CO absorber (6). The rising gas is countercurrently contacted by a descending solution of copper ammonium acetate (copper liquor) which absorbs nearly all the carbon monoxide.

The solution rich in carbon monoxide leaves the bottom of the CO absorber, enters a regenerator (7) where carbon monoxide is released by reboiling. The copper liquor is cooled and returned to the top of the CO absorber to complete its circuit. The carbon monoxide leaving the top of the regenerator is injected into the fuel gas system for the ultimate recovery of its heating value.

The effluent from the CO absorber is the hydrogen product gas and contains essentially 96 per cent H_2 and 4 per cent N_2. The nitrogen enters the process at the generator as a contaminant in both the coke oven gas and oxygen and remains unchanged throughout the process due to its inert properties.

Iron ores relatively free of inert materials and ground to the desired particle size are delivered to the H-iron reduction unit from the raw materials preparations section. Reduction is achieved by processing the ore in a semi-batch process in three fluidized beds. In the reduction vessel the ore is countercurrently contacted with

Figure 3 — Chart shows possible reduction rates for hematite and magnetite.



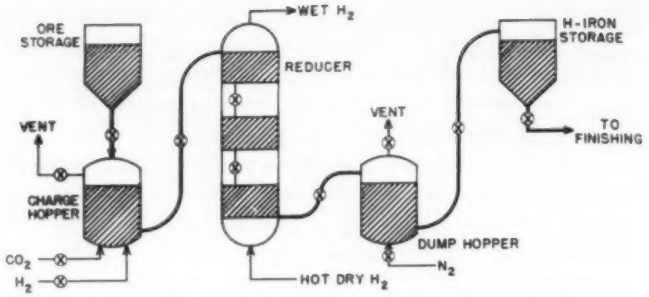


Figure 4 — Movement of solids is shown by this flow diagram.

hydrogen gas at a temperature of less than 1000 F and at a pressure of approximately 500 psi. The relatively low temperature prevents the reduced iron particles from sintering together and sticking to the vessel. The high pressure increases the rate of reduction by improving the contact between the gas and the ground ore. The hydrogen reacts with iron oxide to produce metallic iron and water-vapor according to the equation:

$$Fe_3O_4 + 4H_2 \rightarrow 3Fe + 4H_2O$$

Three beds are required in the reducer for efficient operation due to the decline in the rate of conversion as the reduction proceeds. The rate decline is clearly indicated by Figure 3 which shows the attainable reduction rates for the H-iron process. The total time required to reach 98 per cent reduction is divided into three equal intervals, representing the residence time for the material on each bed of the reducer. The ordinates on the graph for the elapsed bed times indicate about 47 per cent reduction on the first bed, proceeding to 87 per cent on the second and finally to the desired 98 per cent plus on the third bed.

It is interesting to note that in the H-iron process the reduction of magnetite proceeds more rapidly than for hematite. This was of particular interest when the H-iron process was being considered by Alan Wood since magnetite from the company's mines was to be used as the basic raw material.

For ease of understanding the reduction section, the process flow is divided into two interdependent circuits. Figure 4 illustrates the path followed by the solids from ore to H-iron.

Iron ore, in a quantity corresponding to the amount required by a single bed in the reducer is delivered to a charge hopper. The hopper is valved off from the ore supply and purged of air by the introduction of carbon dioxide, a by-product from the hydrogen production section. After purging, the hopper is valved off from the carbon dioxide and then pressured by a slip-stream from the hydrogen circuit. When the pressure in the hopper is about 150 psi higher than in the reducer, the contents of the hopper is delivered through a 1½-in. pipe to the top bed of the reducer by merely opening a valve in the line. Finely ground material in its settled density flows much like water through a pipe from a vessel of a higher pressure to one of a relatively lower pressure. This is known as dense-phase transport. Although the 1½-in. line capacity is high, transferring 15 tons in about 10 minutes, erosion problems are nonexistent since solid line velocities are low.

Before the reducer can receive a batch of ore from the charge hopper, the iron at the desired degree of re-

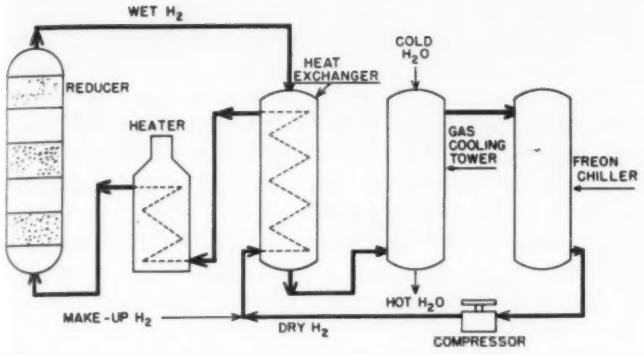


Figure 5 — Hydrogen gas circulation system.

duction on the bottom bed is delivered by dense phase transport to the dump hopper. The partly reduced material on the second bed is then discharged through internal valves to the bottom bed and the least reduced material on the top bed is likewise dumped to the second bed. The batch of ore in the charge hopper is then transferred to the top bed of the reducer. The charge hopper is valved off from the reducer, depressured and readied for another cycle. During the transfers, the reduction vessel remains at full pressure, with fluidization and the flow of hydrogen through the reducer uninterrupted. The intermittent charging of ore and withdrawal of product with the continuous countercurrent flow of gases may be recognized as a close analogy to the operation of a blast furnace.

The dump hopper containing the reduced iron is depressured and purged of hydrogen with nitrogen a by-product from the oxygen plant. The H-iron is then conveyed by dense phase transport to a storage bin and maintained in the nitrogen atmosphere until ready for final processing in the finishing section. Storage under nitrogen is necessary at this point since the H-iron is pyrophoric and cannot be exposed to air.

Essentially, the hydrogen gas circulation system is as shown in Figure 5. Dry hot hydrogen enters the base of the reducer and passes up through the three fluid beds in series. The velocity of the gas through the finely ground ore is maintained at a rate higher than required to buoy up the material. This produces bubbles which cause violent agitation of the solids and provides excellent reducing-gas to ore contact. The hydrogen supplies all the heat for the endothermic reaction of reducing the oxide to metallic iron by removing the oxygen which combines with the hydrogen to form water vapor. Approximately five per cent of the hydrogen is converted to water and leaves the top of the reducer with the unreacted hydrogen.

The effluent from the reducer is partially cooled in an exchanger while preheating the incoming dry hydrogen to the reducer. Next, the gas passing up through a cooling tower is cooled to about 90 F by a descending stream of cooling water. Further cooling of the gas stream to about 55 is accomplished in a freon chiller. Cooling in this manner at the high operating pressure, reduces the water content in the hydrogen to only a few hundredths of a percent.

A portion of the hydrogen stream, vented off to prevent the accumulation of inert gases, is injected into the fuel gas system for the ultimate recovery of its heating value.

The major portion of the dry hydrogen recovers its pressure losses in a recycle compressor and is then joined by a make-up hydrogen stream from the hydrogen production unit. The combined streams are preheated in the heat exchanger while cooling the effluent from the reducer, enters a gas fired heater where it is heated to about 1000 F and finally returns to the reducer to complete the circuit.

The additional processing necessary to produce powder metallurgical grades of iron powder is performed in the finishing section of the plant. The product from the H-iron reduction section, kept in a nitrogen atmosphere to prevent immediate reoxidation by air, need only be raised to a temperature of 1500 to 1600 F in order to render it nonpyrophoric. To accomplish this passivation phase, the H-iron is loaded in pans and thence into a roller hearth furnace, heated to the desired temperature and finally cooled to room temperature in a water cooled zone of the furnace. The entire operation is performed in a nonoxidizing atmosphere.

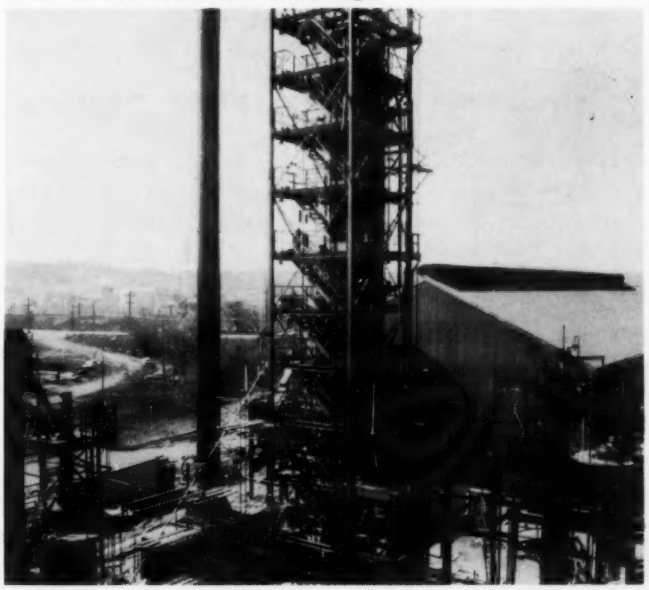
The stabilized product emerging from the furnace is then treated to produce iron powders for various applications. Control of the several properties of the powders is accomplished by a flexible flow of the material through equipment designed to adjust particle size, bulk density, compactibility, green strength, tensile strength, etc. The finished iron powders are blended to assure proper particle size distribution and finally packaged according to customer specifications. Additives may be included during the blending operation to supply the customer with premixed powders of various grades.

The products of the iron powder plant are used for many applications.

Iron powder is incorporated in the flux coating of welding rods to produce electrodes which, under many conditions, provide better welds. In addition, higher welding speeds are obtainable resulting in lower welding costs.

Iron powder is introduced into the flame of the oxy-acetylene torch. The heat of oxidation increases the temperature of the flame and enables cutting and scarfing of stainless steels and other alloys that have heretofore resisted the torch. Cutting of ordinary steels of

Figure 6 — A structural tower is built around the reduction unit for access and servicing.



much greater thickness and of non-metallic refractories are also possible by this method.

Presently, the largest tonnage of iron powder is used for the production of structural parts by the powder metallurgy process. By this process, finely divided metal powders are pressed into predetermined shapes and then heated below the melting point to obtain the required amount of welding of particles to form a strong finished article. The process offers the advantages of speed, elimination of waste material, special properties and low cost for the production of such parts as gears, bearings, bushings and literally thousands of machine parts.

Due to the inherent characteristics of powder metallurgy processing, parts can be made with varied physical properties weak or strong, soft or hard, porous or dense and with close tolerances. Many things can be done with metal powders that cannot be done with regular metals. For instance, bearings and machine parts are produced with a porous structure and impregnated with lubricants for long time lubrication. The selflubricated bearing is one example. Metallic filters are another example of parts with controlled porosity. The combination of metals and nonmetals is still another interesting aspect of fabricating techniques. The production of clutch facings and brake linings previously mentioned are examples. Also, along these lines of friction products, Alan Wood is a consumer of iron powder. A product known as Algrip plate is produced by hot rolling a mixture of iron powder and abrasive on a steel plate backing to produce a positive nonskid floor plate.

Powder metallurgy, as known today, is a relatively new and small industry when compared to other metal working processes. However, in the past 20 years the industry has advanced rapidly and the pace is accelerating. It is our opinion that the potentials are great and that the use of iron powder for powder metallurgical purposes will continue to expand.

Although the Alan Wood iron powder plant was primarily constructed for the production of iron powders for the powder metallurgy industry, other possibilities were considered when designing the plant. During the past few years many articles have been written and many discussions held on the value of direct reduction as a method of winning iron values from ore for the production of steel. For this reason, equipment was installed to briquette the iron powders to produce various type melting stocks. Briquettes are formed with or without carbon and also without residual metals for special applications. It is our intent to determine the practicability of utilizing partially reduced H-iron for replacing purchased scrap and ore in the open hearth; and the H-iron process in conjunction with electric furnaces for the future expansion of steelmaking capacity.

We, at Alan Wood, believe the new iron powder plant will contribute much to the advancement of powder metallurgy and also provide information that will eventually lead to a versatile process of smaller capital cost for the production of steel.

Discussion

PRESENTED BY

H. W. DORSET, Assistant Superintendent, Electrical Dept., Bethlehem Steel Co., Sparrows Point, Md.

L. G. COSCIA, Squad Foreman, Plant Engineering Dept., Bethlehem Steel Co. Sparrows Point, Md.

V. L. MILLER, District Manager, Lee Wilson Engineering Co., Inc., Philadelphia, Pa.

JOHN W. TRAUB, Mechanical Engineer, Alan Wood Steel Co., Conshohocken, Pa.

H. W. Dorset: Is this process a dirty operation, similar to a sintering plant? I assume all of the powder is confined to some kind of vessel or pipe, so that it does not fly around and contaminate the electrical equipment as in a sintering plant.

You stated that you have a 1500-kva transformer bank. What do you use all that power for?

Is the gas you have explosive in any way? Is the hydrogen gas in a pure state? We have hydrogen-filled generators with pure hydrogen, it will not burn, but you spoke of mixing hydrogen and oxygen together.

L. G. Coscia: A recent paper stated that the petroleum industry was very much interested in furnishing hydrogen for an iron powder plant, or any iron powder operation. I was just wondering if you have investigated the uses of tank car, by-product hydrogen from a petroleum plant in connection with your installation, and if so, what are the advantages of coke oven gas?

V. L. Miller: I had the privilege in 1944 of being superintendent of a similar sponge-iron plant, at Republic Steel Corp. The question I would like to ask is has Alan Wood given any consideration to taking the ferrous sulphates from their pickle liquor and winding up with a good iron powder?

John W. Traub: In answer to H. W. Dorset, your assumption that the plant's operations is not dirty is correct because all the storage, flow and processing is accomplished in a system that is totally enclosed.

The 1500-kva, 6900/2300-volt transformer provides the power for all motors 300-hp and larger. At present we have a 400-hp motor on the ball mill, a 400-hp motor on the coke gas compressor and a 500-hp motor on the recycle compressor.

The 2000-kva, 6900/480-volt transformer provides power for all other equipment and general plant use.

Hydrogen alone as it is used in the process is not explosive. Under no conditions are hydrogen and oxygen gas mixed. In the process, the oxygen in the ore combines with the hydrogen to form water. This water is continually being removed.

The contesting of the first plant site by nearby home owners was done mainly because it involved rezoning of a tract of land from "light" to "heavy industry."

In answer to L. G. Coscia, the H-iron reduction process requires very pure hydrogen which cannot be obtained from a petroleum plant as a by-product. The coke oven gas at Alan Wood contains about 55 per cent hydrogen which is an economical source of raw material.

In answer to V. L. Miller, the literature on the direct reduction of iron salts had been studied but was not seriously considered since other investigators were unable to produce good iron powders. In addition, the quantities of iron that would be available from pickle liquor at Alan Wood would not suffice our needs. ▲

Pictorial Roundup

AISE Western Meeting

San Francisco, Calif.

March 7, 8, 9, 1960

BREAKFAST CLUB—Authors and chairmen of the initial technical session assembled for breakfast and a briefing before reporting for work.

The three-day Western Meeting of the Association of Iron and Steel Engineers held at San Francisco's St. Francis Hotel was attended by 520 steelmen from all parts of the country. In keeping with the program which was aimed at topics of prime concern to western steelmen, the local representation contributed the majority of the registrants.

A tour of the Mare Island Naval Shipyard on Wednesday, March 8, concluded the meeting.

▲PUNCH LINE is delivered by H. N. Gumma, Colorado Fuel & Iron Corp., to fellow District Chairmen: W. L. Murphy, Pacific Coast Div., Bethlehem Steel Co., and G. S. Koss and J. S. Moore, Columbia-Geneva Steel Div., United States Steel Corp.

BIRDIE WATCHERS—Camerman catches A. F. Franz, President, Colorado Fuel & Iron Corp.; W. T. Hogan, S.J.; guest speaker; S. C. Read, AISE President; and H. J. McClung, General Manager—Operations, Pacific Coast Div., Bethlehem Steel Co. ▶

▼FULL HOUSE—Stag dinner on Tuesday, March 8, was attended by more than 400 registrants.

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Saturday, May 21, 1960—1:30 P.M.

Annual Stag Picnic

Pittsmans Lake

BUFFALO SECTION

Tuesday, May 31, 1960

Ninth Annual Golf Outing

Wanakah Country Club (Wanakah), Buffalo, N. Y.

CANTON SECTION

Monday, May 16, 1960

Inspection Trip: Empire Reeves Steel Corp., Mansfield, Ohio

CHICAGO SECTION

Tuesday, May 3, 1960

Inspection Trip 2:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Inspection Trip: Acme Steel Co., Riverdale, Ill. There will be a tour of the plant before visiting the oxygen steelmaking facilities. Those taking trip will assemble at the parking lot west of the Acme Steel main gate at 134th and Perry Streets. In-plant busses will be provided there.

"Oxygen Steelmaking Facilities," by Frederick M. Gillies, Chairman of the Executive Committee, Acme Steel Co., Riverdale, Ill.

Dinner and Meeting, Phil Smidt's Restaurant, 1205 North Calumet Ave., Hammond, Ind.

CLEVELAND SECTION

No May Meeting

COLORADO SECTION

Tuesday, May 17, 1960—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"CF&I Mining Department," by R. R. Williams, Manager, Mining Dept., The Colorado Fuel and Iron Corp., Pueblo, Colo.

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Saturday, May 21, 1960

Spring Dinner Dance

Detroit Yacht Club

LOS ANGELES SECTION

Data not available

PHILADELPHIA SECTION

No May Meeting

PITTSBURGH SECTION

No May Meeting

ST. LOUIS SECTION

Saturday, May 21, 1960—2:00 P.M., Picnic—"Pot Luck" Dinner at 6:00 P.M.

American Legion Park, Edwardsville, Ill.

SAN FRANCISCO SECTION

Friday, May 6, 1960

Golf Party, Mt. Diablo Country Club, Danville, Calif.

Tuesday, May 17, 1960—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Columbia-Geneva Steel Division Night

"Wire Rope & Strand Producing Facilities at Pittsburg Works," by Gerry P. Snyder, Wire Rope Engineer, Metallurgy and Inspection Dept., Pittsburg Works, Columbia-Geneva Steel Div., United States Steel Corp., Pittsburg, Calif.

Shattuck Hotel, Shattuck & Allston Way, Berkeley, Calif.

UTAH SECTION

Monday, May 9, 1960—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"The Search for Iron Ore," by S. G. Sargis, Assistant Manager Exploration, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, May 23, 1960

Inspection Trip 3:00 P.M., Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Inspection Trip: Youngstown Sheet and Tube Co., Seamless Tube Mill, Youngstown, Ohio. Assemble at buses at 3:00 P.M., behind Campbell Works Administrative Building.

Discussion of plant by John H. Stone, General Superintendent Flat Rolled and Tubular Products, and Stephen Muryn, Assistant Chief Engineer, Electrical, Youngstown Sheet and Tube Co., Youngstown, Ohio

Dinner and Meeting, Mahoning Country Club, Girard, Ohio

ELPIT electric soaking pits supplement fuel-fired pits in English Mill shown above.

RUST now brings you *quality heating* with ELPIT® electric soaking pits

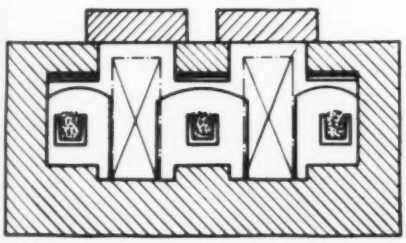


Diagram indicates simplicity of design . . . far less expensive to install than a fuel-fired soaking pit or furnace. Eliminates necessity for such auxiliary equipment as chimney, flues, recuperators, control valves and slag pits. Low maintenance costs.

Another "first" brought to you by RUST . . . the ELPIT . . . successful in over forty European installations. It consists essentially of a well-insulated steel casing, without flues or stacks, resting on a simple concrete foundation. Electrodes through the end walls connect with heating elements. Energy is transmitted mainly by radiation resulting in *highly uniform heating.* Temperature and power control are fully automatic.

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Ring Rolling Plants Designed For Automatic Operation

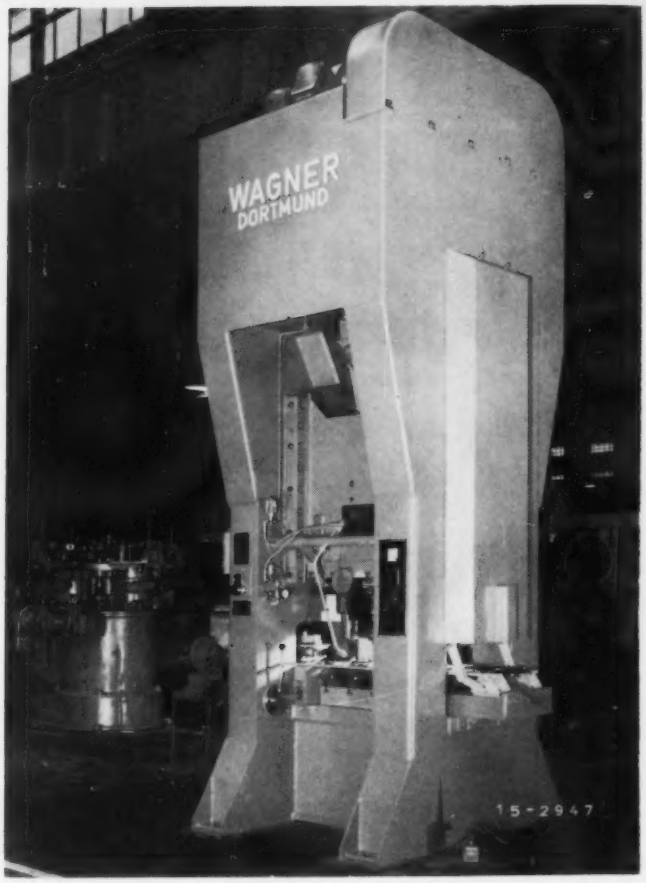


Figure 1 — The forging press has a compensating device which produces pierced and formed blanks of exactly the same volume.

NEWLY developed, fully automatic ring rolling plants have been put on the market by Wagner & Co. of Dortmund, Germany. Rings or ring blanks, required in large numbers, such as roller and ball bearing races, ring springs, gear rings, gear wheels, et cetera, can generally best be manufactured by hot forging on presses, followed by rolling on ring rolling mills. Rings formed in this way are of much higher physical quality and more accurate in shape and dimensions. Moreover, the proper combination of such equipment costs considerably less than any other single machine or combination of machines able to form comparable shapes at comparable rates. Over-all material loss is considerably less.

Up to now, however, such presses and ring rolling mills were available only with manual handling and controls. Output was limited by the physical capabilities of the operators. In order to increase output and to save manpower, two new machines have been developed: A forging press, Type Pda, with a compensating device which produces pierced and formed blanks of exactly the same volume from eccentrically cut or broken billets, and with a mechanical feed which automatically picks up the heated billet, transfers it from station to station under the dies, and passes on the preformed blank to the ring rolling mill. (Figure 1).

A ring rolling mill, Type KFRWa, which operates continuously with automatic handling devices to pick up the pressed blanks, position them on the mandrel rolls, and remove finished rolled rings (Figure 2).

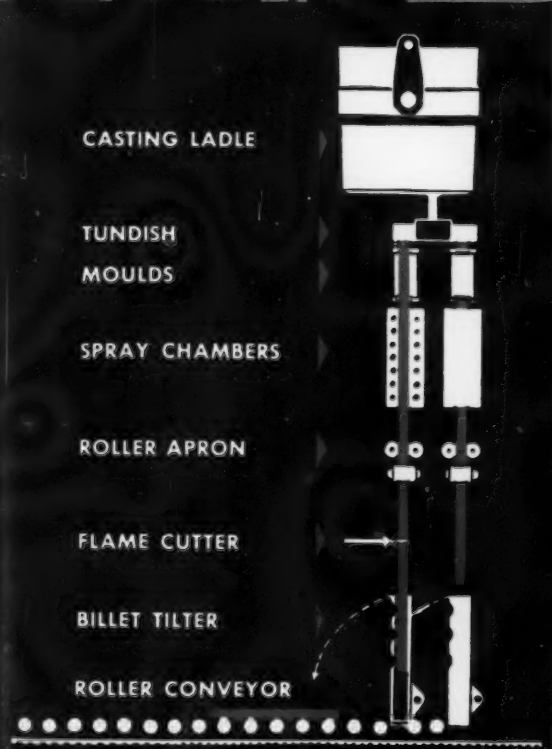
An automatic transfer device between the induction heating unit and the press conveys the heated billets to the feeding mechanism of the press. This feeding mechanism moves the workpiece automatically from one to the other of three die positions—upsetting, preforming and punching—finally passes it on to the automatic handling mechanism of the ring rolling mill.

To finish roll rings to correct shape and precise dimensional tolerances, the rolling mill must be fed ring blanks of uniform shape and exact volume. Heretofore, this was best achieved by sawing billets to exact lengths. Or, under somewhat less exacting conditions, broken or sheared billets were sorted by weight classes to which press tools were reset and adjusted. This is not necessary with the Pda forging press.

This newly developed press guar-

DEMAG

CONTINUOUS STEEL CASTING PLANTS



EIGHT-STRAND CASTING PLANT

in full operation at the Terni iron and steel works in Italy since 1958

Developed to the Junghans system in co-operation with Messrs. Mannesmann and Böhler

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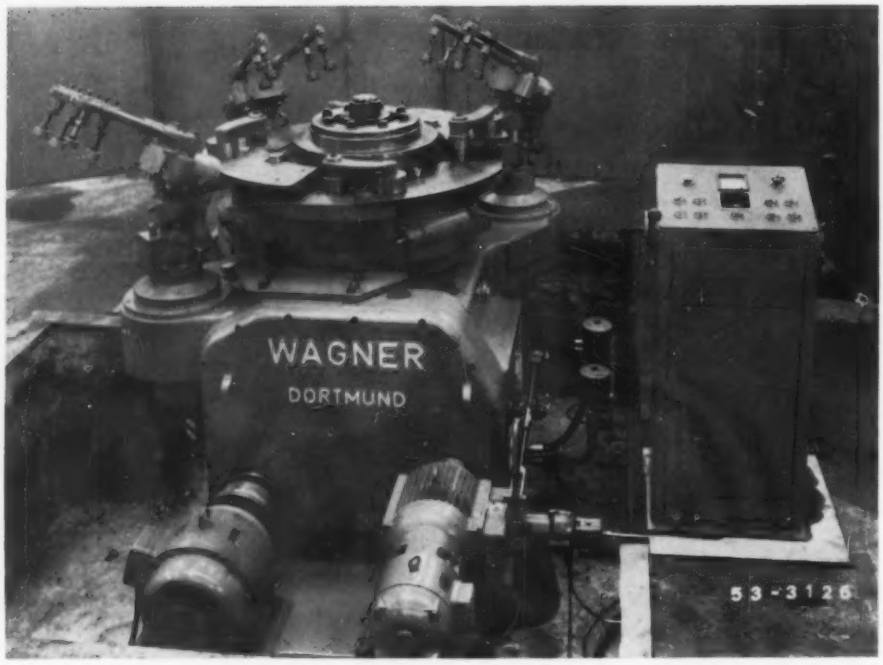


Figure 2 — The ring rolling mill has automatic handling devices.

antees preformed ring blanks of uniform shape and accurate volume from any normal run of broken or sheared billets. This is achieved by a compensating device in the second press die station. Here the upset billet is expanded by a punch into the surrounding closed die cavity. This punch is, however, hydraulically cushioned so that it stops its downward movement when the die cavity is filled. Therefore, the metal directly under the punch, the center web, is always excess. It may vary in thickness according to variation in billet volumes, but the volume of the surrounding blank remains the same. Therefore, by punching out these webs in the third press station, pierced blanks of precisely uniform volume are obtained. From such identical blanks the ring rolling mill automatically rolls rings of identical diameters.

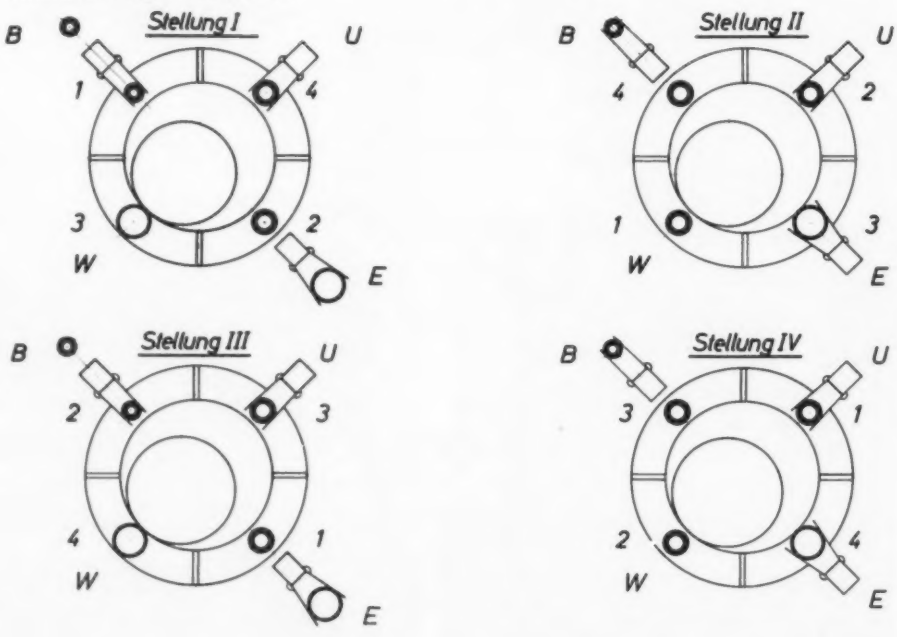
It is also noteworthy that no outside flash or internal burrs are formed on the ring blank during these pressing operations. Because of the hydraulic cushion on the preforming punch, no outside flash cavity is needed around the enclosing die ring, and the piercing punch always enters the piece from the opposite side to prevent burrs. Obviously presses of this type can be profitably applied to many other forging operations, as well as to preforming for ring rolling.

The KFRWa ring rolling mill works in two operations with two roughing and two finishing mandrel rolls. The ring blank coming from the press is picked up by tongs mounted on the rolling mill and is rotated to the first roughing mandrel where it is lowered and released. See Figure 3. The eccentrically mounted table rotating on the king shaft, brings this mandrel with the blank into the area marked "rolling." At "W" the mandrel roll is closest to the profile roll. Here the ring blank is expanded to the desired dimension. The expanded ring passes by station "E" to station "U." Here it is picked up by the tongs at station "U," held and then placed on the next following finishing mandrel roll, which passes closer to the king shaft and the profile roll. At station "W" the ring is this time brought to the required final dimensions. At station "E" the removal tongs pick it up from the finishing mandrel, turn it 180 degrees, and drop it onto a chute or conveyor.

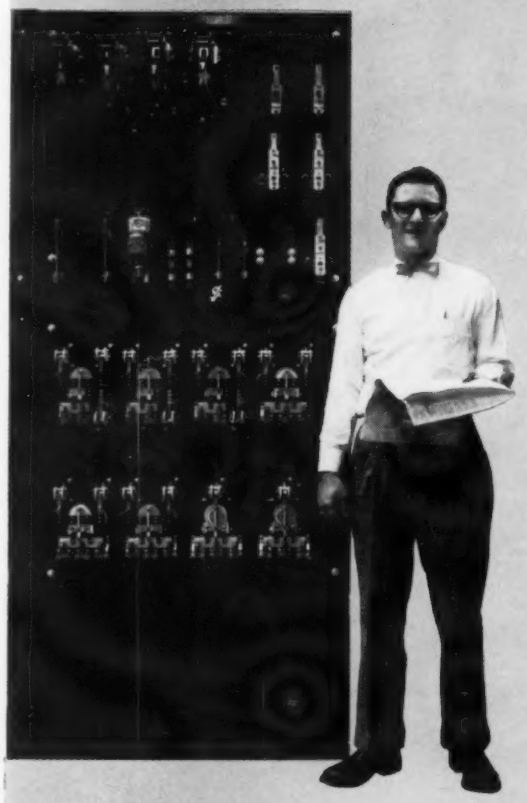
The four mandrel rolls line up with stations "B," "E" and "U," for each of these transfers, because the speed of the rotating table reduces to zero as the mandrel rolls come to these stations. The same applies to the rotating tongs at the stations "B" and "E." They are, however, coupled with the rotating table in a 2 to 1 ratio, so that a 90 degree turn of the table corresponds to a 180 degree turn of both tongs. The tongs at stations "B," "E" and "U" also move up and down as well as in rotation.

Both the press and the rolling mill thus work as an automatic unit, the mechanical feed of the press passing the blank to the handling

Figure 3 — Sequence of operations is as follows: In upper left, which is position I, 1 B is feeding a blank, 2 E passes by, 3 W finishing rolling and 4 U roughed ring is put on finishing roll. In position II, upper right, 1 W is rough rolling, at 2 U roughed ring is lifted from roughing mandrel, at 3 E finished ring is removed and at 4 B passes by. In position III, shown lower left, at 1 E blank passes by, at 2 B is feeding the blank, at 3 U roughed ring is put on finishing roll and 4 W is finish rolling. At position IV, shown lower right, at 1 U roughed ring is lifted from roughing mandrel, at 2 W rough rolling, at 3 B blank passes by and at 4 E finished ring is removed.



"Reliance's mill-type control does the thinking...this unique cold mill does the rest.



R. M. Bosshardt, Manager,
Heavy Duty Metal Rolling Section,
Reliance Electric & Engineering Co.

"The terms 'precision' and 'versatility', as applied by the makers of this new 'Pittsburgh' 4/high-2/high combination cold mill, also exactly describe the Reliance mill-type heavy industry control. Smooth functioning and easily maintained, this control is slate mounted for safety and quick accessibility.

"The mill itself in 4/high is used for cold reducing; in 2/high, it tempers and finishes. A 250 hp. Reliance D-c. mill motor is coupled to a gear reducer which drives 2 output shafts which can be applied to either set of rolls depending on the operation. Utilization of full motor speed range produces a maximum of 300 feet per minute on 8" or 20" rolls. The reel is driven by a 100 hp. D-c. motor with two VSR regulators: one to match speed of the mill, the other to maintain tension. Reel is automatically changed . . . and an all-electric control quickly recalibrates reel drive system for either 2/high or 4/high."

The result is two-fold: extreme product accuracy . . . smooth economical operation. Reliance Sales Engineers can quickly apply their talents and products to your manufacturing system needs. Call your Reliance office, or write us direct for complete product and application information. L-1650

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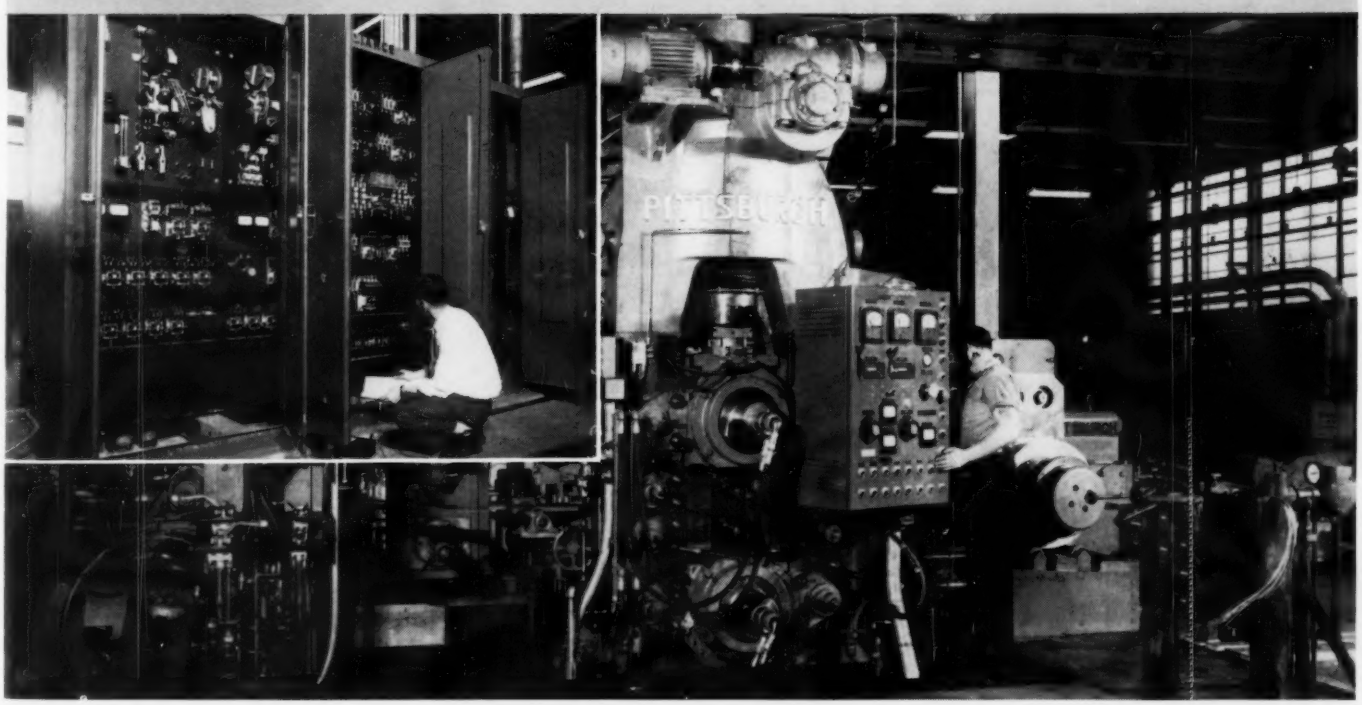
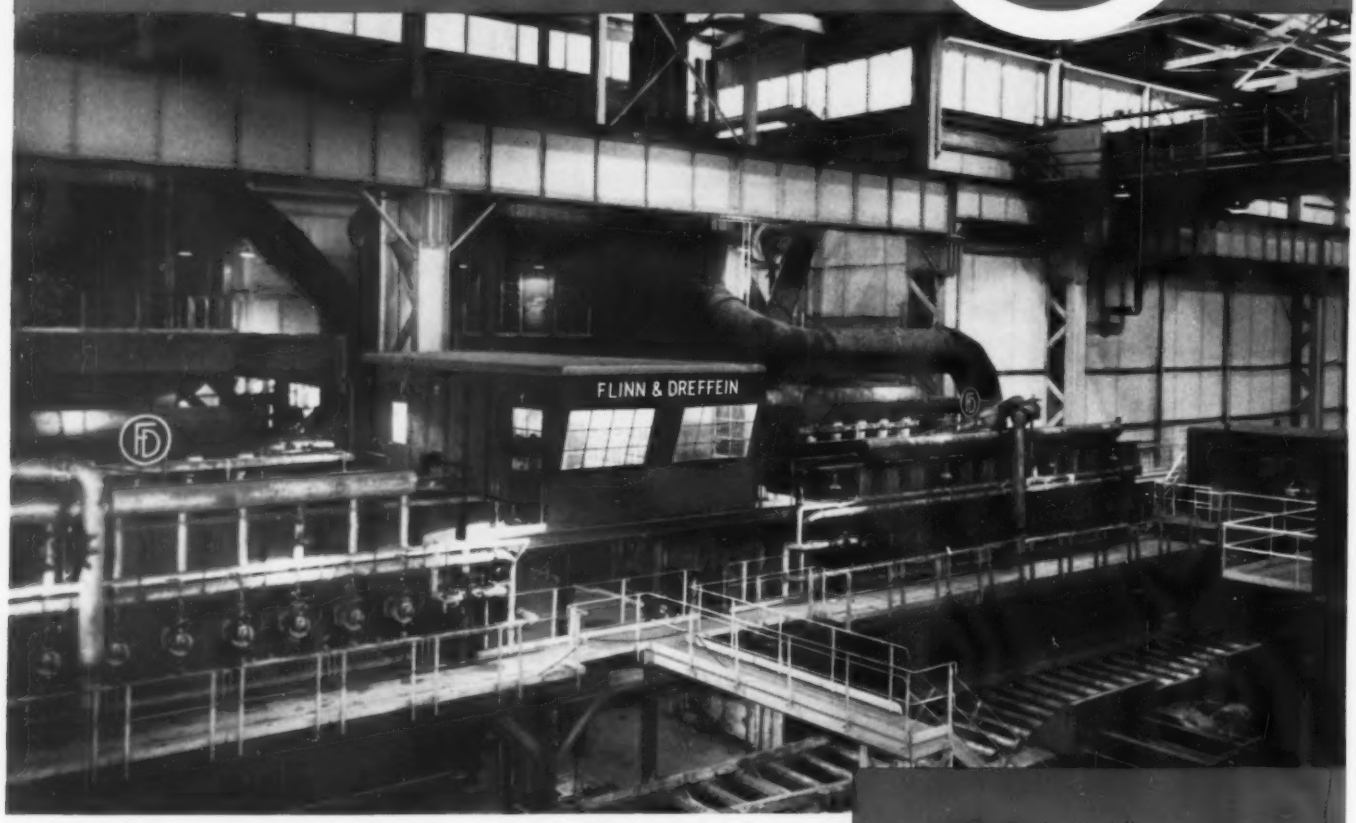


. . . another first by Flinn & Dreffein . . .



Two new "Flinn & Dreffein Designed" 5-zone reheat furnaces made news recently when they were placed in operation at the new structural mill of United States Steel Corporation's South Works plant at Chicago.

The demand for larger sections, tonnage capacities and flexibility of heating operation dictated this advanced design.

Once again, Flinn and Dreffein experience and know-how reflected by user's confidence inspired Flinn and Dreffein engineers to further the development of reheat furnaces using the latest techniques and materials in furnace design.

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FLINN & DREFFEIN ENGINEERING CO.
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equipment of the mill. Before the first of two new automatic machines were even completed in Wagner's shops, metalworking specialists suggested that the combination of automatic press and automatic ring rolling mill be expanded into a complete line, equipped with all necessary units to permit fully automatic production of rings. Therefore, a plant has been designed in which the press and the ring rolling mill have been coupled with an induction heating plant and a billet breaker by means of appropriate transfer and conveyor units. This is a complete manufacturing line which starts with bar stock and produces finish rolled rings in a continuous, fully automatic sequence of operations.

Such an automatic ring rolling line begins with billet preparation. This can be either shearing or notching and breaking. (Slower and more costly sawing is not necessary with the Pda press.) The trend is toward notching and breaking equipment because users of automatic rolling lines, such as bearing and automotive manufacturers, normally prefer, for reasons of economy, to use round cornered square billets, unannealed. These billets are usually of forging quality steels having a high tensile strength and low limit of elasticity, and they can, therefore, readily be broken. For this purpose Wagner has designed a combination of notching machine and billet breaker with automatic feed. Broken billets are conveyed from the breaker to weighing scales, preset to reject automatically pieces above or below a certain weight range. Such rejections are usually only end sections of the original bars, but exceptionally eccentric breaks can also cause excessive weight variations, with consequent automatic discarding of the affected pieces.

Broken pieces within the weight tolerance pass from the scales onto a vibrating conveyor which feeds the induction heating unit. This type of feeder was selected to provide a well arranged, uninterrupted flow of pieces to the heating and forming equipment. Normally such a conveyor can accommodate enough pieces for up to two hours production, thus it provides a natural reserve and uninterrupted flow of pieces despite the more intermittent output of the billet notching and breaking equipment.

Billets can be heated in any reliable, well controlled furnace with automatic feed. However, Wagner has designed its lines to include only induction billet heaters for several reasons. Good ring rolling practice requires uniformly heated billets having a minimum of scale and induction heating provides this. Many of the steels used in quantity ring production are highly susceptible to decarburization, and this has to be minimized in the finished rolled ring. The relatively short heating cycle with induction equipment keeps decarburization at a low level. Moreover, for such continuous, line-flow hot working, induction billet heaters have the additional advantages of good efficiency, small production space requirements, cleanliness, low heat radiation to surrounding air and equipment, ease of control, and simple convenient material feeding and handling possibilities.

The induction billet heating unit normally employed is of the walking beam type with highly precise temperature controls. ▲

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produces temperatures never before achieved with oil or natural gas.Burning oil, it can reach a searing 3450°F. On 1000 BTU/cu. ft. natural gas, it develops 3320°F. Both these extremely high temperatures are close to the theoretical limits for these two fuels. Foundries, smelters, heat treaters and other metal processers have been quick to take advantage of the remarkable combustion efficiency of these new burners. To them, it has meant faster heating cycles, cleaner flue gases, and above all, fuel economy that cuts from 12% to 30% from their furnace overhead. Not to speak of reduced maintenance on refractory linings.

To learn how the Bliss Burner can increase the heat output in your plant while it's saving you money in fuel and furnace maintenance, write today for our Bulletin No. 60. It's yours for the asking.

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E. W. BLISS COMPANY
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Republic To Spend $159,000,000 In 1960

CAPTIAL expenditures of over $159,000,000 are scheduled for Republic Steel Corporation for 1960, the largest expenditures for capital purposes ever made by the company in a single year. The expenditures are part of Republic's $375,000,000 five-year drive to improve the efficiency and versatility of the company's operations.

Principal projects programed, not previously announced include the installation of hot strip finishing facilities and a 48-in. continuous heavy gage strip galvanizing line at Republic's Warren plant; an additional battery of coke ovens and a plastic coating line for steel pipe at the Youngstown plant; relocation and rehabilitation of the 8-in. bar mill at the Canton plant; a block of additional soaking pits at the Buffalo plant; special heat treating facilities at the Chicago plant; a new battery of coke ovens and coal chemical producing facilities, and additional soaking pits at the Gadsden, Ala., plant.

Previously announced were Republic's plans for building a 56-in. hot strip mill at its Warren plant and a 134-in. plate mill at Gadsden. These projects are under way as are some of the other listed projects.

Several major projects are under consideration for the Greater Cleveland area. However, Republic's Cleveland steel plant is handicapped by lack of space for expansion of production facilities and for the storage of raw materials. A program to make more usable space within the confines of Republic's present property by culverting Morgana Run as it passes through Republic's property is under study by the company and city officials.

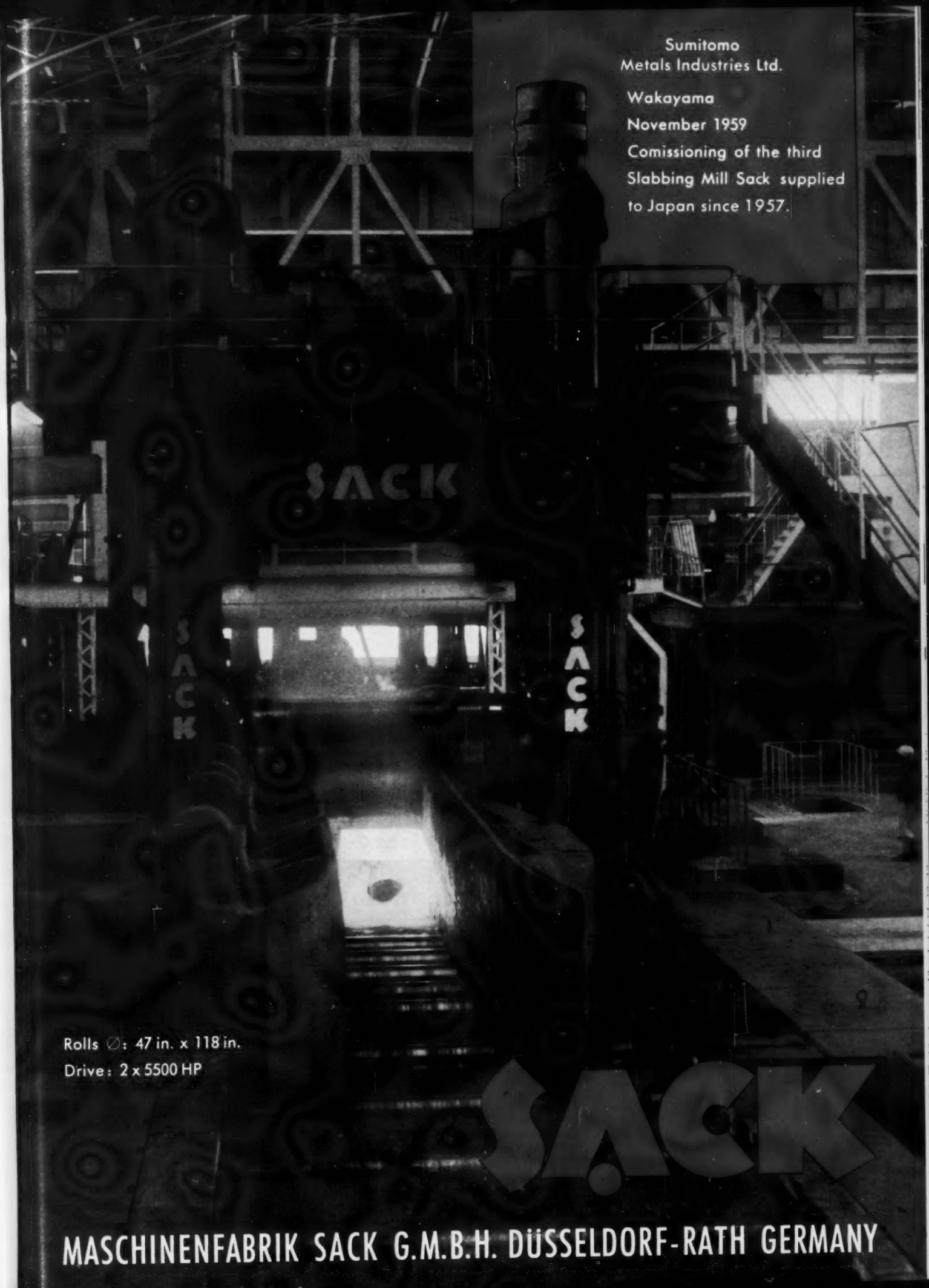
Plans have been approved and funds appropriated for improvements at two Republic coal mines in western Pennsylvania. At Belle Vernon, Pa., a coal washing plant will be built and a new mine opened, to be known as Banning No. 4. Improvements are also being made at the company's Republic Ky., mine.

The largest part of the 1960 capital expenditures will be spent in the Youngstown-Warren area where Republic operates two large steel plants.

Republic's spending program, while aimed primarily at improving efficiency, will, nevertheless, result in an increase of 330,000 tons in basic steel ingot capacity. In Warren, handling equipment in the open hearth department is being improved with an expected increase in steel capacity of 192,000 tons per year resulting. In Gadsden, one open hearth furnace is being enlarged with an expected increase in annual capacity of 138,000 tons. Republic's steel capacity was 12,742,000 tons, as of January 1, 1960.

The various projects are being financed largely through depreciation and retained earnings but some additional borrowing may be undertaken if deemed desirable. The company's long-term debt as of December 31, 1959, amounted to $94,885,537, or only about 12 per cent of total capitalization. ▲

Figure 1 — Construction is well underway on a new 56-in. hot strip mill at Republic Steel Corp.'s plant in Warren, Ohio. The mill is expected to be in operation early in 1961. Figure shows some of the foundation work already completed.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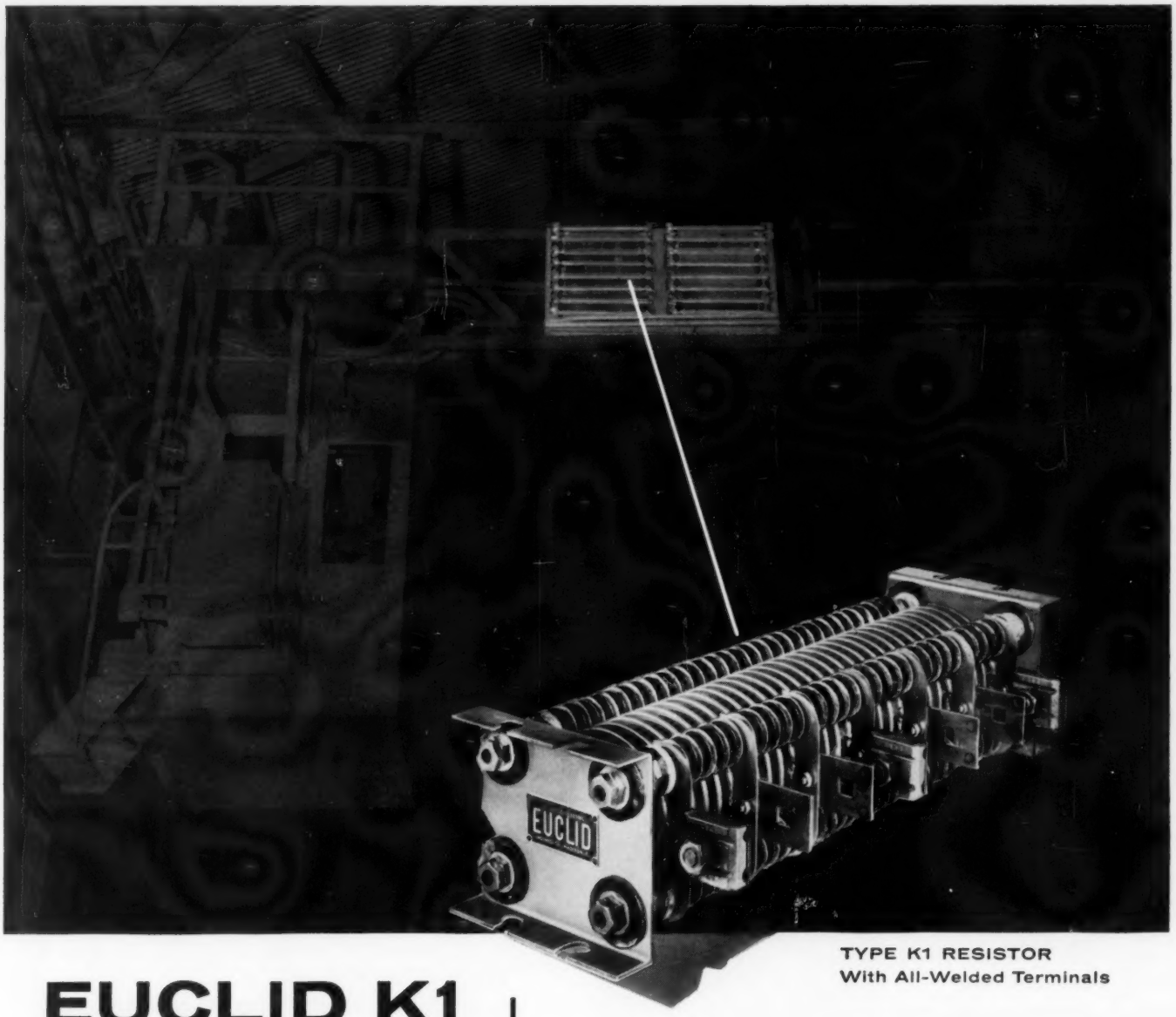

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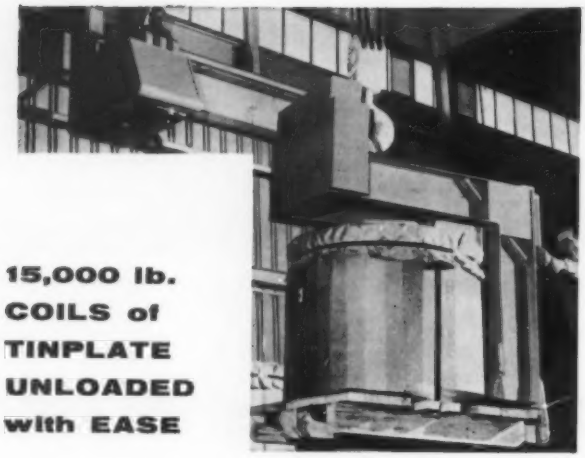

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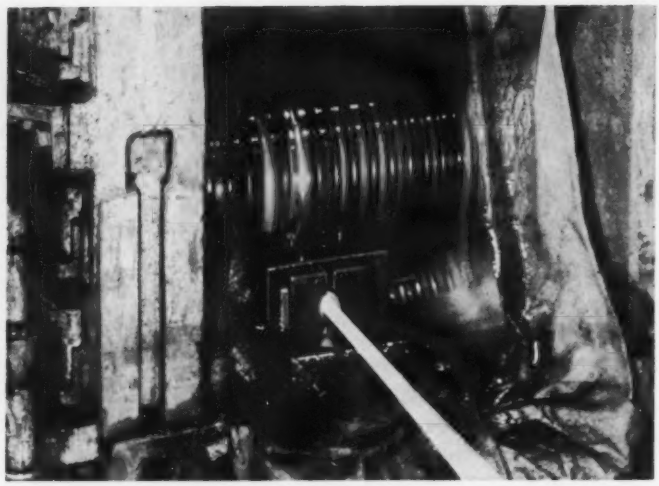

Near-white-hot rod enters roller guide housing, and forming rolls beyond. Colmonoy hard surfacing rebuilds worn guides, gives them longer life than before.

Colmonoy Cuts Roller Guide Reclamation Cost

Hard-surfacing alloys that are easy to apply save welding time. And it follows that finishing time is also reduced—easy-applying alloys produce smoother deposits. Time is money, and the maintenance department of a large stainless steel bar mill saves money by using Colmonoy No. 6 alloy to reclaim worn roller guides. With Colmonoy they reclaim three guides in the time it took to do one previously.

The superior wear-resistance of Colmonoy No. 6 added more savings by extending even further the service life of the guides. All roller guides in this plant are reclaimed with Colmonoy—again and again, indefinitely.

Colmonoy alloys are being used in many mill operations: on plate guides, edger rolls, journal sleeves, and coolant-pump parts. Write for complete information.

Smoothness is the notable characteristic of these Colmonoy-protected guides prior to finishing.

Roller guide being overlaid with Colmonoy No. 6 rod. Work rotation is operator controlled.

Ready for further service are these finished guides with mirror-bright Colmonoy surfaces.

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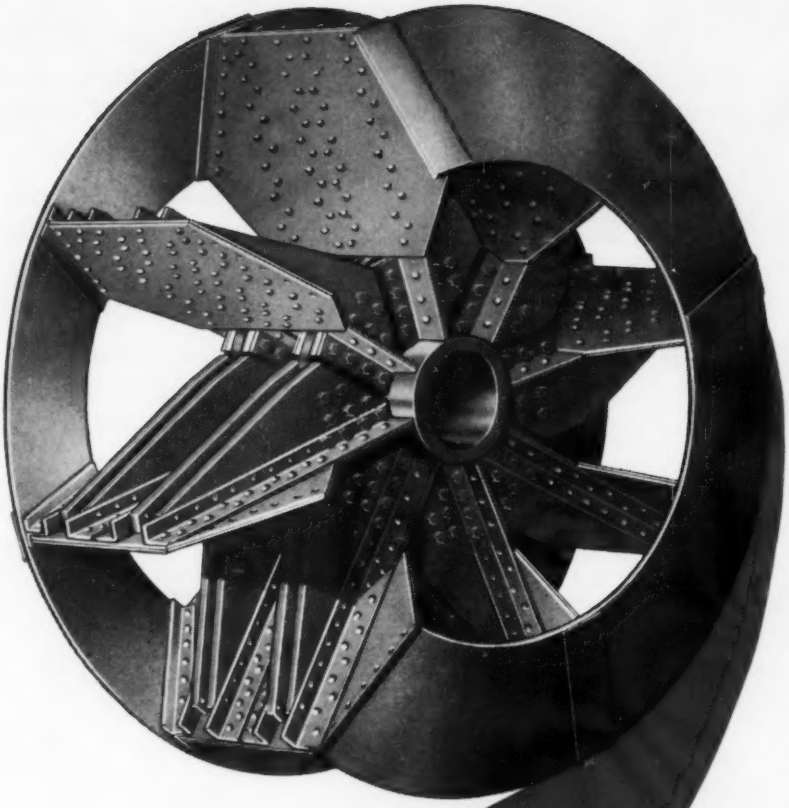


Here's a rugged giant of a fan for sintering!

Green *Sintering Fans*

Specially Developed To Withstand Punishing Everyday Operation

This fan won't punch a time clock! The heavy duty battleship construction and extreme erosion resistance assures you dependable service and *longer life*.

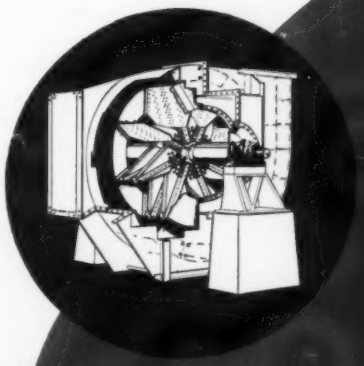
CUSTOM ENGINEERED: No Green Sintering Fan is a stock fan. Each Green Sintering Fan is specifically designed and engineered to meet your particular requirements.

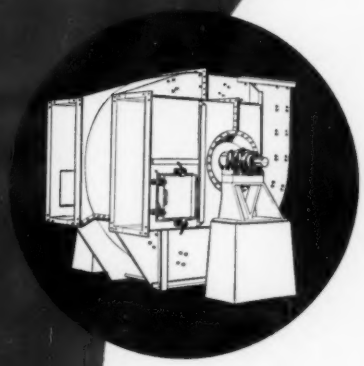
Careful stress studies of every cubic inch of material in a Green Fan are made to meet the tip speeds of 30,000 fpm, or more, necessary for pressures required in sintering.

EROSION RESISTANT: Erosion of fan blades is a serious and ever present sintering problem. Green Fans are designed to keep necessary maintenance time and expense to a minimum. With unique blade design and thick blade liners, erosion problems are drastically lessened. Green blade liners, incidentally, may be replaced without the removal of the rotor.

BUILT-IN SAFETY: Green Sintering Fans are designed to limit operating speed to 66⅔% of first critical speed. Material safety factor at operating temperature is never under 2.

Green custom designed Sintering Fans offer you minimum annual expense and maximum dependability. Write for information and details.





A major steel producer has installed six of these Green Sintering Fans. Each fan produces 360,000 cfm at 35 in. static pressure at 740° F.

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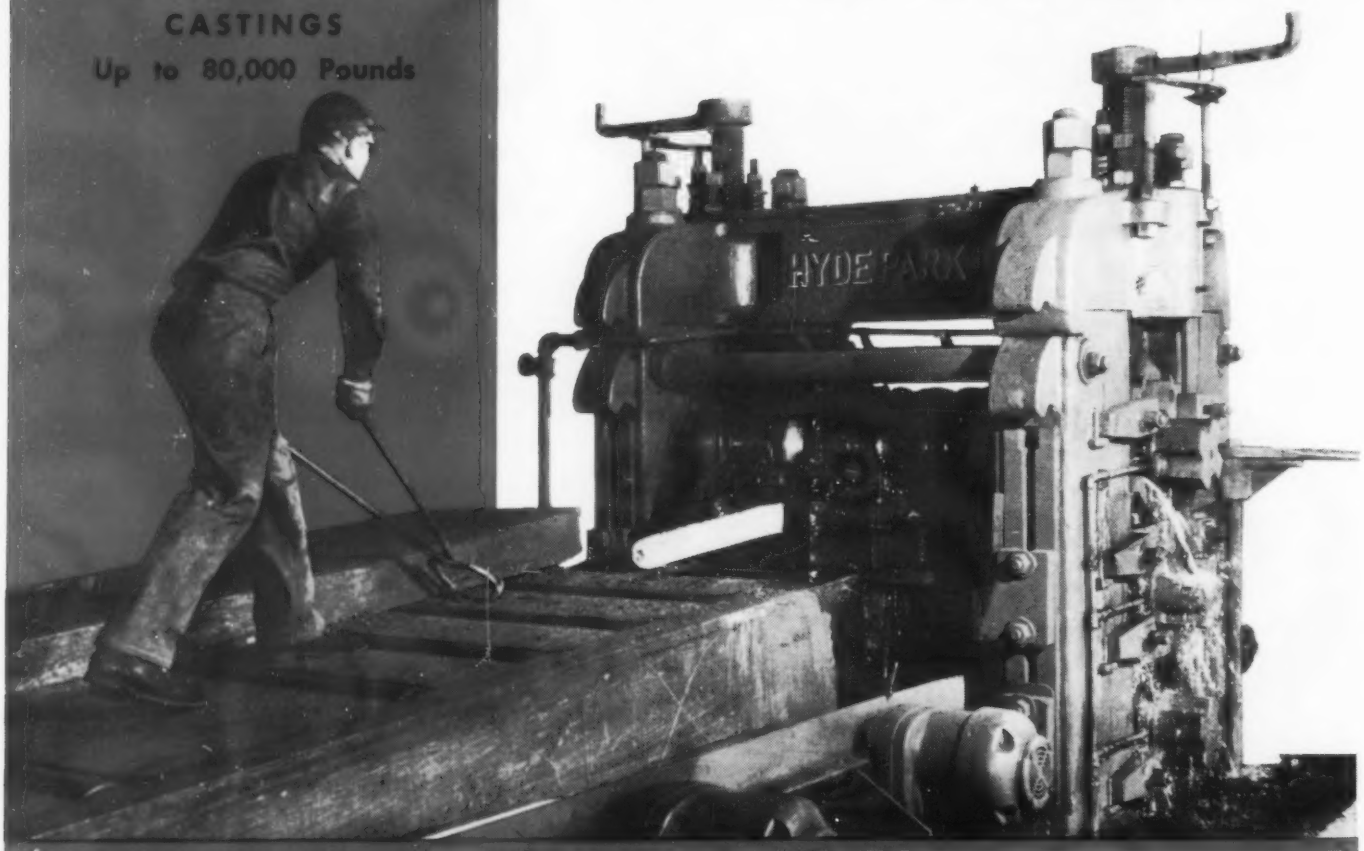

Photograph showing Hyde Park 18" 3-Hi Bar Mill Stand at Florida Electric Steel Mill, Tampa, Florida.

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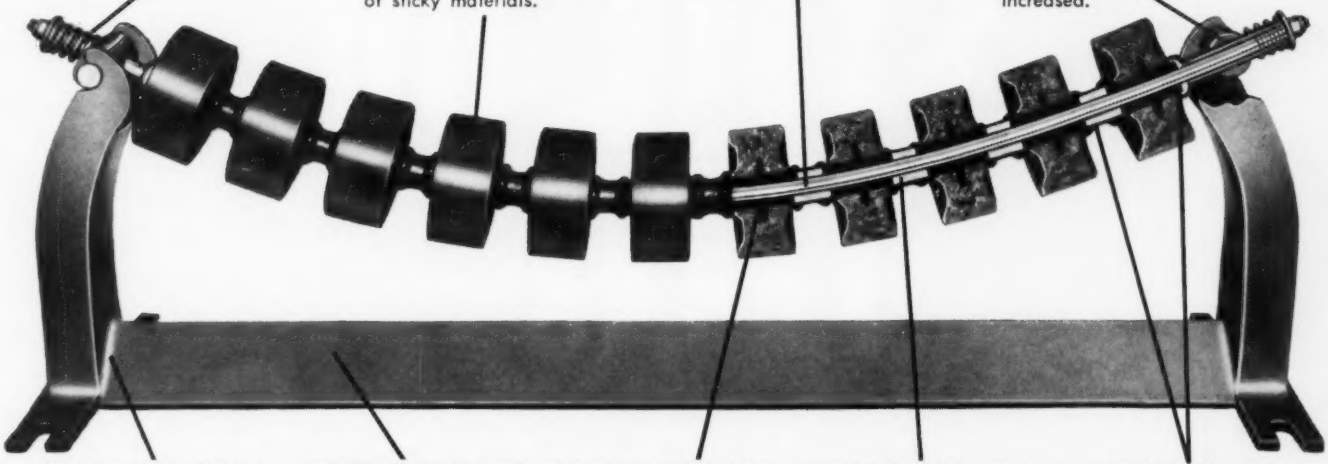

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SELF-CLEANING FRAME—Inverted angle cross-member and self-cleaning end-brackets prevent material from collecting and fouling rollers.

NYLON BEARING GRAPHITE IMPREGNATED—Ensures long life without maintenance. No lubrication required.

NYLON SPACERS—Positive connection between rollers is achieved by mating jaws of nylon spacer and bearing of roller.

DUST SEALS—Protects bearings from ingress of foreign matter.

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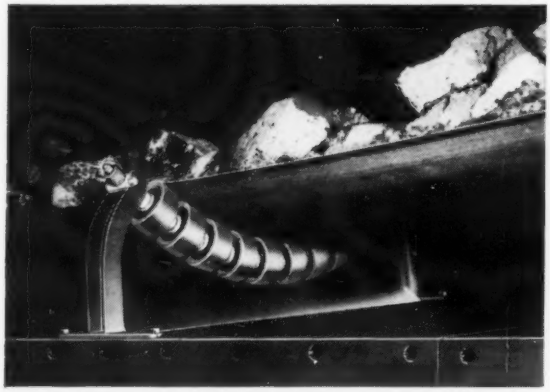

Closeup of a 30" S-A FLEXIROLL Catenary Idler in operation on belt conveyor handling coal. There is no fire risk with the FLEXIROLL and material breakage is reduced to a minimum.

- Resists corrosion, abrasion, grease, flame, oil, clogging and freezing.
- Increases belt training and greatly reduces belt wear.
- Both idler and stand self cleaning—eliminate material build-up.
- No metal to metal contact—flexing of idler prevents dust build-up, eliminating fire risk.
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- One-third the weight of all-metal idlers—saves space, weight in supporting structures.
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- All-steel flanged and jig welded frames.
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Date-line Diary...

March 1

Δ U. S. Dept. of Commerce, Bureau of the Census, reports that shipments of nonferrous castings in December, 1959, totaled 202,658,000 lb compared with 175,729,000 lb in November, 1959.

Δ Bureau of the Census reports that production of titanium mill products in December, 1959, amounted to 725,314 lb, compared with 474,312 lb in November, 1959, and 561,577 lb in December, 1958.

Δ The joint report by American Iron Ore Assn. and AISI shows that receipts of iron ore and ore agglomerates in the United States for the fourth quarter, 1959, totaled 25,571,865 gross tons compared with 25,916,861 gross tons in the same period 1958; consumption in the U. S. during this period in 1959 amounted to 20,222,954 gross tons, compared with 27,977,495 gross tons in the same period in 1958. Receipts for year 1959 totaled 91,525,345 tons compared with 90,976,975 in 1958. Usage in 1959 totaled 94,398,015 tons compared with 89,781,164 in 1958.

Δ Allis-Chalmers Manufacturing Co. reports that 1959 sales totaled $539,640,773, net profit $22,864,963 or $2.47 per share, compared with sales of $531,972,829, net profit $19,657,958 or $2.34 per share for the year 1958.

Δ National Machine Tool Builders Assn. reports, for the year 1959, total shipments of $413,050,000, foreign shipments $47,550,000, net new orders $509,000,000.

March 2

Δ The Commerce Dept. reported that manufacturers inventories in January, 1960, were increased to an adjusted $53,200,000,000, up $750,000,000 in the month. New orders received by manufacturers in January ran at a seasonally adjusted rate of $29,700,000,000, a decrease of $1,000,000,000 under December, 1959, and $1,100,000,000 below the adjusted sales volume.

Δ Automakers produced 659,303 cars during February, 1960, 4 per cent under the January, 1960, production rate and 38 per cent over February, 1959.

Δ Commerce Dept. estimated construction outlays in February, 1960, at $3,600,000,000, 4 per cent below January, 1960.

March 3

Δ Commerce Dept. reported U. S. imports of foreign goods in January, 1960, decreased to $1,100,000,000, down 24 per cent from imports in December, 1959.

Δ Youngstown Sheet and Tube Co. disclosed plans to raise capital spending to about $85,000,000 in 1960, aimed at relieving bottlenecks in finishing facilities and lowering costs. The company spent $75,000,000 in 1959.

March 4

Δ The Bureau of Mines reported that the production of Pennsylvania anthracite for February, 1960, was 1,567,000 net tons compared with 1,634,000 tons in January, 1960, and 1,557,000 tons in February, 1959.

March 7

Δ The Board of Directors, Kaiser Steel Corp., deferred consideration of a dividend on the common stock until further recovery from the effects of the 1959 steel strike.

Δ Pittsburgh Coke & Chemical Co. reports, for the year 1959, sales totaled $70,023,000, net income amounting to $2,725,000 or $1.98 per share; compared with 1958 sales totaling $45,513,000, net income $1,296,000 or 75¢ per share.

Δ The AISI reports that the operating rate of the steel industry, for the week of March 7, is scheduled at 2,647,000 tons (92.9 per cent of capacity). This compares with 2,645,000 tons one week ago (92.8 per cent capacity) and 2,604,000 tons one year ago. Index of production for the week is 164.8.

March 8

Δ The Aluminum Assn. reports that net shipments of aluminum sheet and plate in January, 1960, totaled 106,971 lb, compared with 121,753 lb in December, 1959. Shipments for the year 1959 totaled 1,507,790 lb. Shipments of aluminum foil in January, 1960, amounted to 17,593,430 lb, compared with 17,852,388 lb in December, 1959.

March 11

Δ The AISI reported that steelmaking furnaces in the U. S. poured 11,119,000 net tons of ingots and steel for castings during February, 1960, compared with 12,049,404 tons in January, 1960, and 9,602,938 tons in February, 1959.

Δ The AISI reports shipments of finished steel products direct from mills during January, 1960, totaled 8,429,696 net tons, an increase of 218,000 tons from December, 1959, shipments.

Δ Custom smelters are offering refined copper at 33¢ per lb, 2¢ lower than previous quotations, matching the price quoted by U. S. copper producers since early November.

March 14

Δ The AISI reports that the operating rate of the steel industry for the week of March 14 is scheduled at 2,597,000 tons (91.1 per cent of capacity). This compares with 2,654,000 tons one week ago (93.1 per cent capacity), and 2,631,000 tons one year ago. Index of production for the week is 161.7.

March 15

Δ International Nickel Co. of Canada, Ltd., reports for the year 1959, net earnings amounting to $85,157,000 or $5.83 per share compared with $39,665,000 in 1958 or $2.71 per share.

Δ The Bureau of Mines reports that consumption of scrap in January, 1960, totaled 7,040,000 gross tons, pig iron 7,016,000 gross tons, compared with 7,021,870 tons of scrap and 6,905,787 tons of pig iron in December, 1959.

March 16

Δ The Census Bureau reported that housing starts fell to a seasonally adjusted annual rate of 1,115,000 units in February, 1960, an 8 per cent decline from the January pace. The Labor Dept. reported that unemployment in February, 1960, dropped to 3,931,000 a decline of 218,000 from January; total employment in February rose to 64,500,000 an increase of 500,000.

Δ United States Steel Corp. reports for the year 1959 average number of employes 200,329, average hourly earnings $3.78, average weekly hours 35.1, average weekly earnings $132,610 compared with 1958 employes totaled 223,490, average hourly

earnings $3.50, average weekly hours 34.2, average weekly earnings $119.70.

March 17

Δ The Commerce Dept. reported that personal income in February, 1960, set a seasonally adjusted annual pace of $393,000,000,000, $200,000,000 above January, 1960, pace and $22,000,000,000 above the rate of February, 1959.

Δ AISI reports that the steel industry's employment of hourly and salaried workers in January, 1960, totaled 640,933 compared with 629,463 in December, 1959, and 558,014 in January, 1959. The payroll for hourly and salaried workers combined for January, 1960, totaled $398,789,456, compared with $400,274,576 in December and $335,154,861 in January, 1959. Hourly rate in January was $3.399 compared with $3.343 in December and $3.313 in January, 1959, excluding estimated employe fringe benefits costing 0.45¢ an hour on the average during 1960. Total hourly costs were $3.849 in January, 1960, against an average of $3.798 during 1959 which includes employe benefit costs of 38.1¢.

March 18

Δ The Hanna Mining Co. reports for 1959 net profit of $7,751,730 equal to $5.42 per share of common stock compared with net profit of $8,090,327 or $5.66 per share in 1958.

Δ The AAR reports that deliveries of new freight cards in February, 1960, totaled 5052, compared with 2849 in January, 1960, and 2486 in February, 1959. Orders in February, 1960, totaled 3411, compared with 7149 in January, 1960, and 1803 in February, 1959. Backlog of cars on order as of March 1, 1960, totaled 46,323, compared with 48,170 on order February 1, 1960, and 28,789 on March 1, 1959.

March 19

Δ Shareholders of The Youngstown Sheet and Tube Co. were asked to authorize an expansion of the board of directors from 11 to 15 members; to increase the authorized common shares from 5,000,000 to 15,000,000, primarily to permit a stock split if, at some later date, the board of directors considers it advisable; and to grant standby authority for one year for the issuance of convertible bonds, at the discretion of the board of directors. All three proposals will be acted upon at the annual meeting of shareholders in Youngstown on April 26.

March 21

Δ Auto dealers' stocks of new U. S.-built cars climbed to 1,012,000 units early in March.

Δ The AISI reports that the operating rate of the steel industry for the week of March 21 is scheduled at 2,554,000 tons (89.6 per cent of capacity). This compares with 2,607,000 tons one week ago (91.5 per cent capacity) and 2,631,000 tons one year ago. Index of production for the week is 159.0.

March 22

Δ Latrobe Steel Co. reports for the year 1959 sales totaling $28,513,000, net earnings of $2,053,000, equal to $1.65 per share; for 1958 sales totaled $17,937,000, income $464,000 or $1.04 a share.

Δ The Aluminum Assn. reports production of primary aluminum in the United States in February, 1960, totaled 156,826 short tons compared with 164,024 tons in January, 1960, and 142,116 tons in February, 1959.

Δ Stockholders of Detroit Steel Corp., at the annual meeting on April 11, will be asked to increase the number of authorized shares to 6,000,000 from the present 4,000,000.

Δ The Bureau of the Census reports that shipments of commercial steel forgings in January, 1960, totaled 122,219 short tons compared with 114,424 tons in December, 1959, and 112,926 tons in January, 1959; unfilled orders on January 31, 1960, totaled 420,583 short tons, compared with 420,118 tons on December 31, 1959, and 353,349 tons on January 31, 1959. The Japan Iron & Steel Federation reports production of pig iron in December, 1959, totaled 990,000 net tons, ingot steel 1,755,000 net tons; for the year 1959 pig iron production totaled 10,492,000 net tons, ingot steel 18,285,000 net tons.

March 24

Δ Resistance Welder Mfr. Assn. reports that shipments of resistance welding equipment during February, 1960, showed 62 per cent increase over January, 1960; bookings in February, 1960, amounted to nearly $3,750,000, a gain of 13 per cent over January, 1960.

Δ American Iron Ore Assn. and AISI joint report indicates that receipts of iron ore and ore agglomerates in the U. S. for January, 1960, totaled 4,659,836 gross tons compared with 3,157,963 gross tons in January, 1959; consumption in January, 1960, amounted to 11,855,949 compared to 9,831,641 tons in January, 1959. In January 31, 1960, blast furnaces in operation totaled 226 of the existing 258, compared with 202 in operation as of January 31, 1959.

March 25

Δ The AISC reports that shipments of fabricated steel products in February, 1960, totaled 240,850 tons compared with 209,031 tons in January, 1960; bookings in February, 1960, totaled 288,825 tons, compared with 221,222 tons in January, 1960. Backlog on order as of February 29, amounted to 2,189,234 tons.

Δ U. S. Dept. of Commerce, Bureau of the Census, reports net shipments of aluminum pig and ingot in January, 1960, amounted to 121,587,000 lb, compared with 213,210,000 lb in December, 1959, and 125,729,000 lb in January, 1959; shipments of aluminum mill products in January, 1959, amounted to 250,116,000 lb compared with 268,017,000 lb in December, 1959, and 236,926,000 lb in January, 1959.

March 28

Δ Bureau of Census reports that shipments of iron and steel castings in January, 1960, totaled 1,342,546 short tons compared with 1,321,147 tons in December, 1959, and 1,180,349 tons in January, 1959.

Δ The AISI reports that the operating rate of the steel industry for the week of March 28 is scheduled at 2,527,000 tons (88.7 per cent of capacity). This compares with 2,597,000 tons one week ago (91.1 per cent capacity) and 2,636,000 tons one year ago. Index of production for the week is 157.3.

March 29

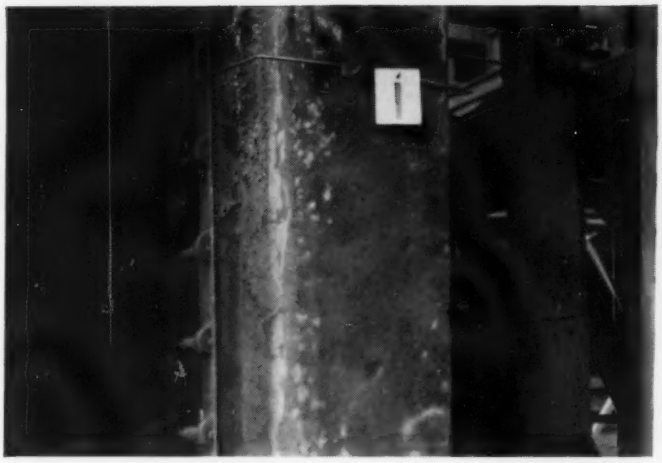
Δ Bureau of the Census reports that shipments of nonferrous castings in January, 1960, totaled 209,608,000 lb compared with 202,742,000 lb in December, 1959. The Bureau of the Census reports that shipments of titanium mill products in January, 1960, totaling 796,538 lb compared with 725,314 lb in December, 1959; and 547,140 lb in January, 1959.

March 30

Δ Bethlehem Steel Co. announced its steelmaking capacity at Baltimore will be increased nearly ten per cent over the next two years as part of the company's $197,000,000 expansion progam at several plants.

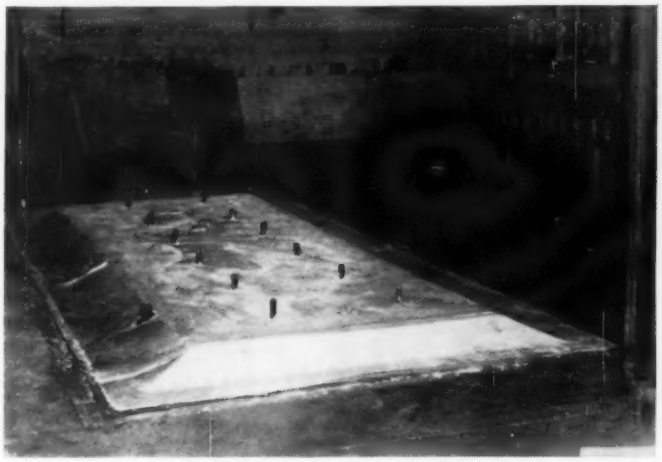
March 31

Δ Key grade of steel scrap declined $1 a ton in Pittsburgh to $35 on No. 1 heavy melting scrap.



B&W Kaocrete-D, vibrated in place, provides high resistance to the atmospheres encountered in this coke oven door installation. Furthermore, the high erosion resistance and long service life without loss of strength of B&W Kaocrete-D add to its suitability in this application.

A typical monolithic curb wall construction in an annealing furnace using a carbon monoxide atmosphere. The greatly reduced number of joints in which sealing sand can penetrate prevents structural spalling of B&W Kaocrete-A upon heating and cooling. Being monolithic, gas leaks are practically eliminated.



A radiant tube annealing furnace with a base of Kaocrete-A, backed up with Kaolite-20, one of B&W's insulating refractory castables. This furnace operates at approximately 1700 F in a 65% CO atmosphere.

A stack annealing furnace with pedestals cast of B&W Kaocrete-A. The atmosphere is slightly above 8% CO. B&W Kaocrete-A offers strength, volume stability and resistance to carbon monoxide disintegration.

How B&W refractory castables perform in atmosphere applications

One of the difficult problems facing furnace builders and operators in the metals industries is the effect of atmospheres on refractory linings. That's why B&W offers several *specialized* refractory castables for this service, each possessing strength, volume stability and the refractoriness necessary to assure long, trouble-free service.

Take B&W Kaocrete-A, for example. Because of the careful selection and processing of special aggregates and other ingredients with low iron content, this material resists disintegration or other effects produced by high concentrations of CO or H_2 atmospheres. B&W Kaocast and Kaocrete-32 provide the same excellent service at higher temperatures while lightweight Kaolite-20 is outstanding as an insulating castable in atmosphere applications.

B&W Bulletin R-35A gives additional information on versatile B&W refractory castables. Write for your copy of this bulletin to The Babcock & Wilcox Company, 161 East 42nd Street, New York 17, N. Y.

R632

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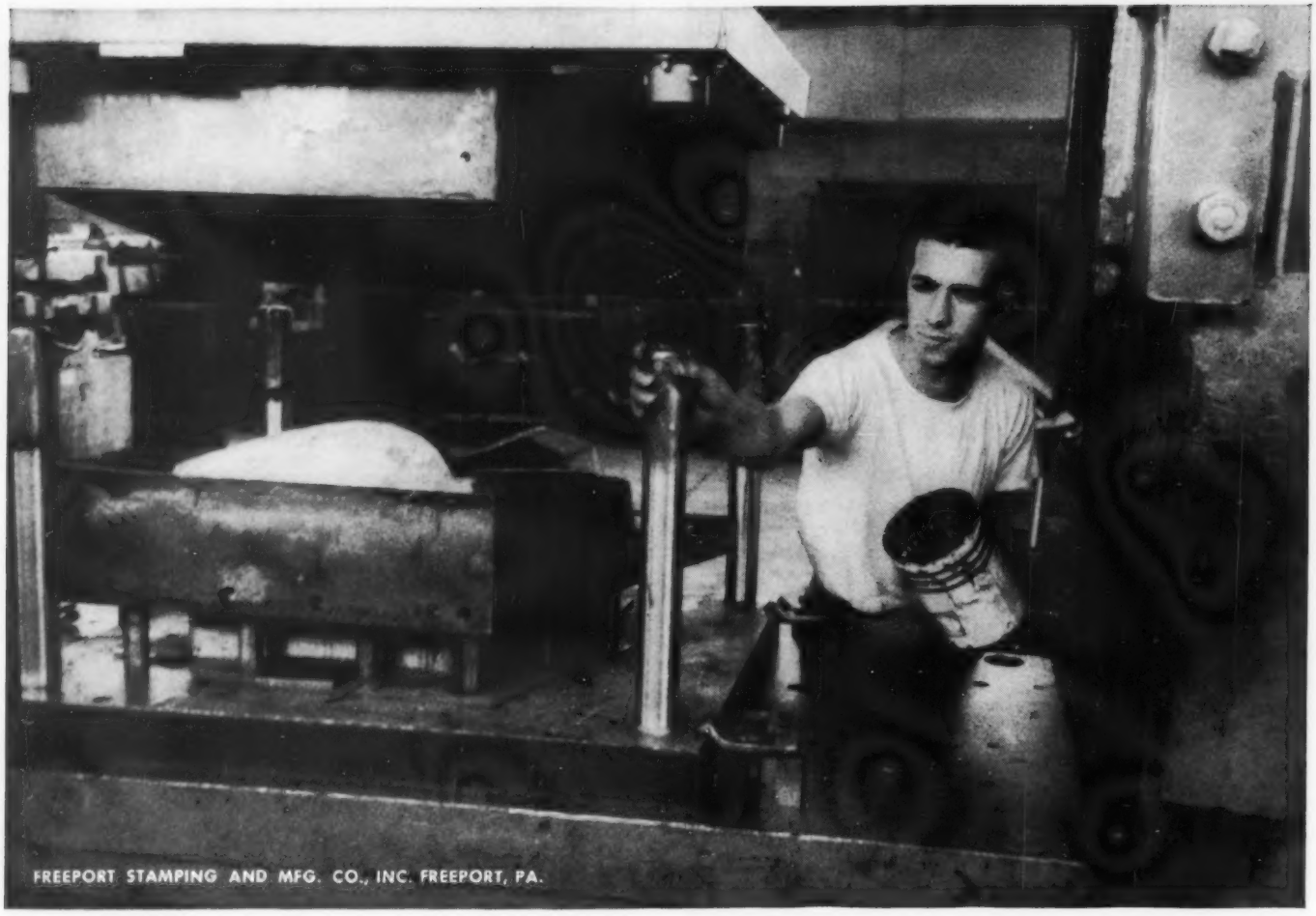

"Die Guides Needed Grease Every Few Hours... Cities Service Trojan HM Stays for Days"

Freeport Stamping has built a reputation for ultra-precision in its stampings. But one annoyance kept bothering the production department . . . die guides had to be lubricated every few hours or they started to bind and gall. Cities Service Lubrication Engineer, Robert Vey, suggested a change to new Trojan HM Grease, containing 3% molybdenum disulfide.

The very first application of Trojan HM kept the die guides operating smoothly for three days instead of the usual three hours. Cities Service Trojan HM Grease is a new lithium base lubricant combining high temperature characteristics with excellent low temperature pumpability, good water-resistant properties and high stability. New Trojan HM Grease is a tenacious lubricant with a plating action that extends the period between servicing.

If you have a grease problem, Cities Service is eager to serve you with free technical assistance and a full line of special and multi-purpose greases. For full information call your nearest Cities Service office or write: Cities Service Oil Company, Sixty Wall Tower, N. Y. 5, N. Y.

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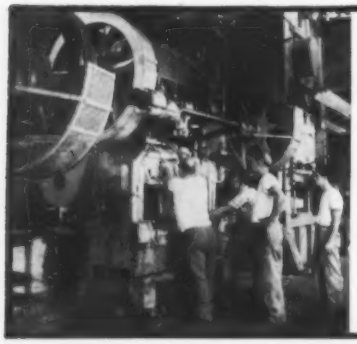
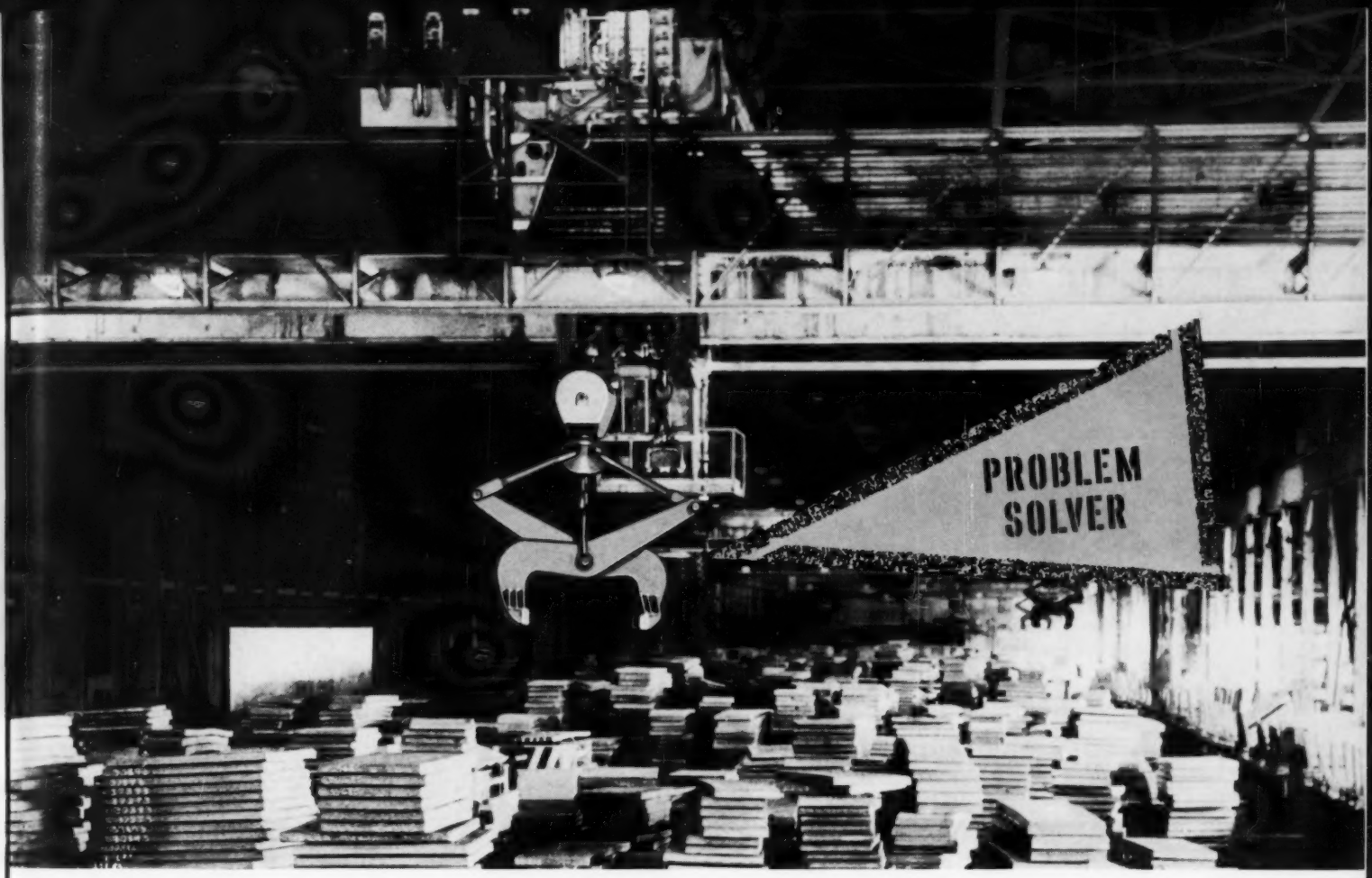
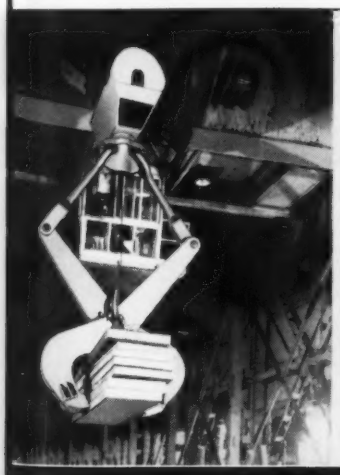


All Eleven presses at Freeport Stamping operate with Pacemaker #3 hydraulic oil. Pacemaker is a multi-use quality lubricant that helps reduce inventory. Freeport also uses Pacemaker in machine tools, and electric motors.

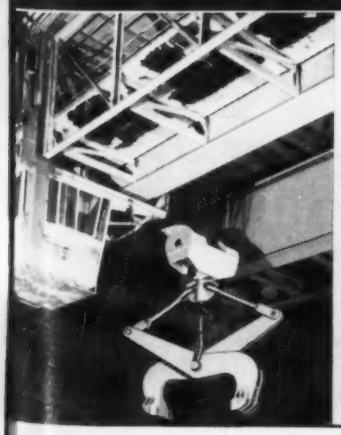
Compound Curves with one draw are possible with Cities Service Drawing Compound. Automobile parts being made for two major manufacturers, are used in a visible spot so they must be free of die marks as well as precision drawn.



TONGS put a tight grip on safety and economy



The tong jaws open to 76½ inches. They are operated by a separate hoisting unit with cable connected to the pivot point of the tongs.



The cab on these cranes is air-conditioned for operator comfort. It is supported from and travels with the trolley overhanging the rear girder.

Inland Steel Company gave up chains, spacers, and "hooker" manpower in piling slabs in No. 2 Slab Yard at East Chicago, Ill. Time proved the method unsafe for both "hooker" and crane, and inefficient as well. The chains often hung-up and had to be pulled free by the crane operator. Haphazard piling also robbed the yard of storage space.

Inland Steel's plant engineers and Shaw-Box engineers solved the problem. Now five "Shaw-Box" Cranes with unique tongs handle an average of 60,000 tons of slabs a week. They are 120-foot span cranes with 50 and 25 ton hooks, each with a lifting speed of 40 FPM. All slab piling is handled from the cab which travels with the trolley. Slabs are piled far neater than before, and many more can be stored in the same area.

Since their erection in 1957, all five cranes have proved their quality in dependable service. The same creative engineering has made great problem solvers of all types of Shaw-Box Cranes, whether built to AISE specs or individual standards of construction and performance. We welcome the opportunity to serve you.

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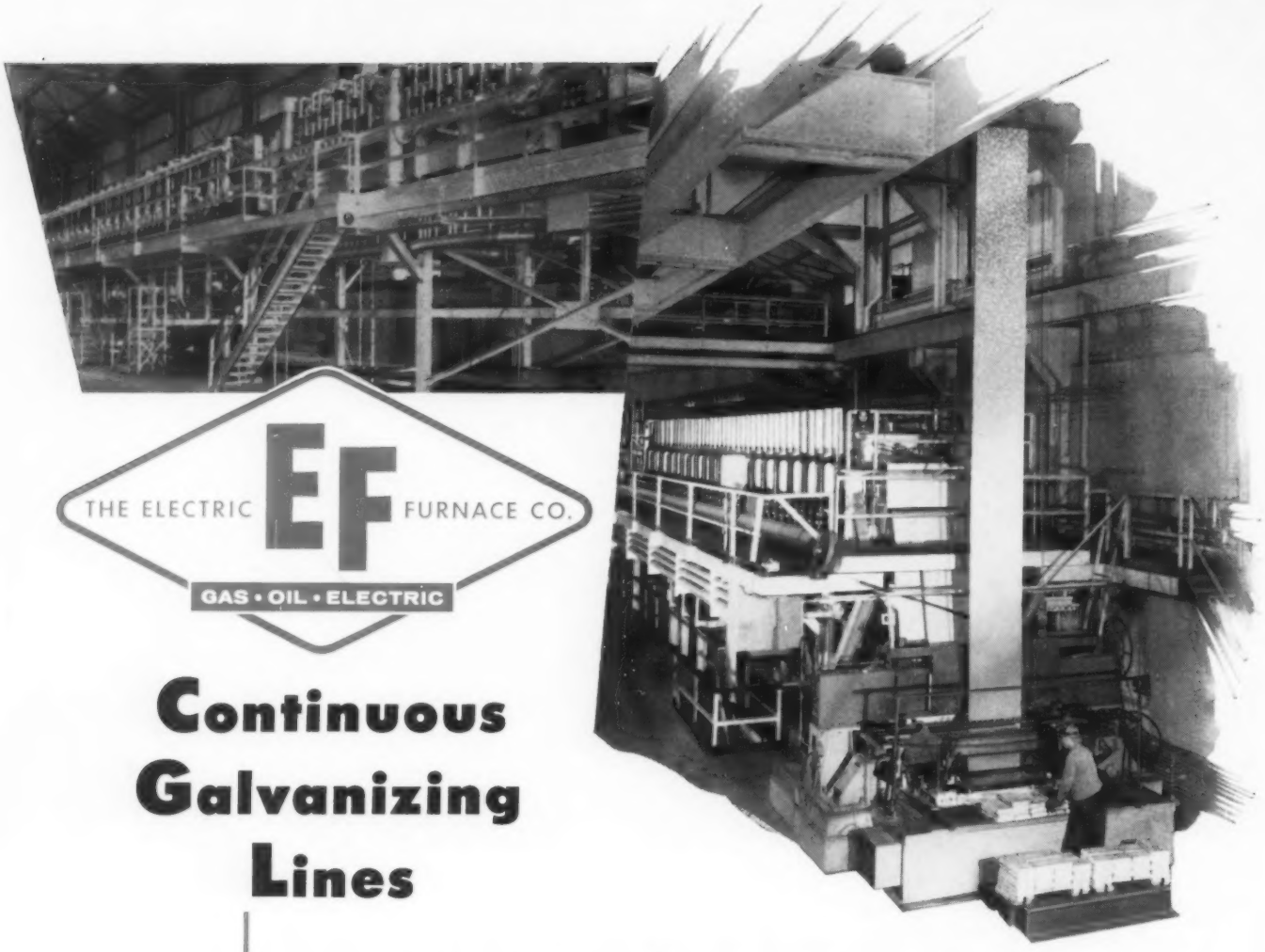

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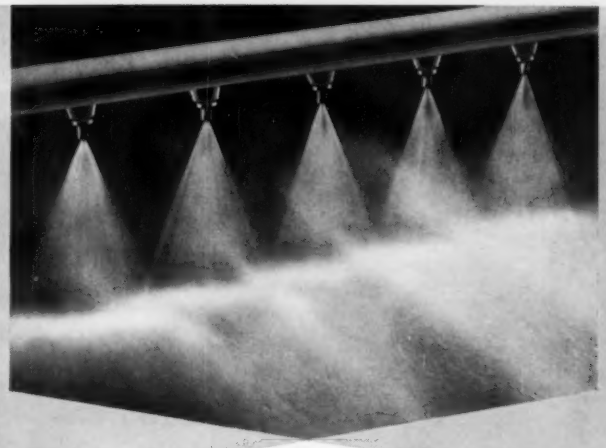

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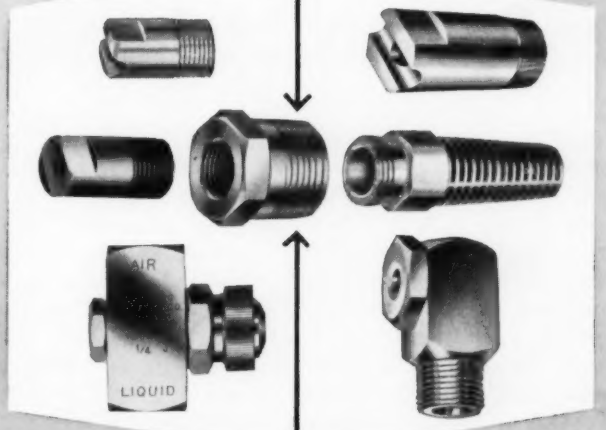

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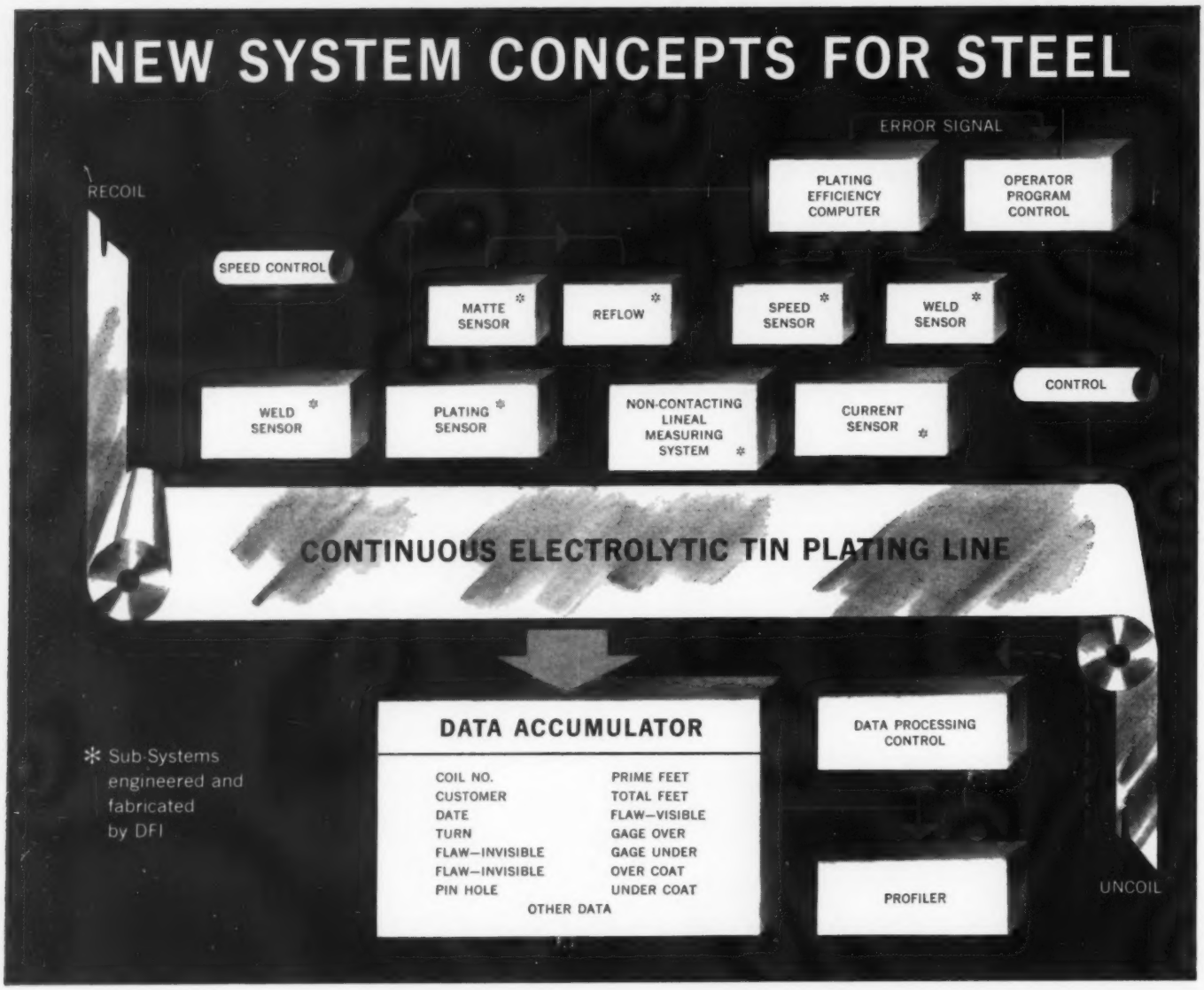

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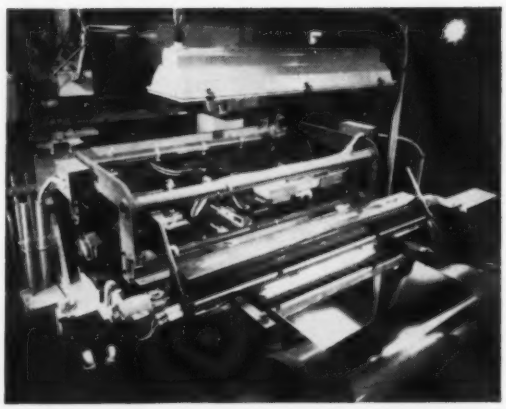

DfI Non-Contacting Lineal Measuring System in operation at Western Pennsylvania tin plate mill. This particular unit "senses" footage with an accuracy of .1% over a dynamic speed range of 300 fpm to 2400 fpm.

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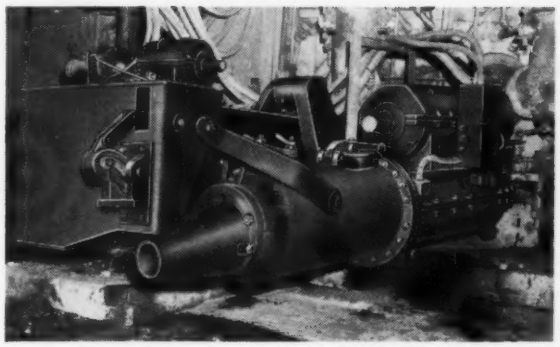

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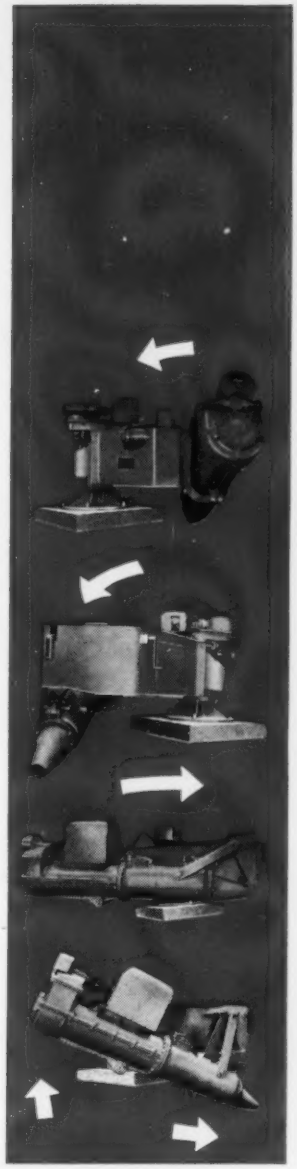

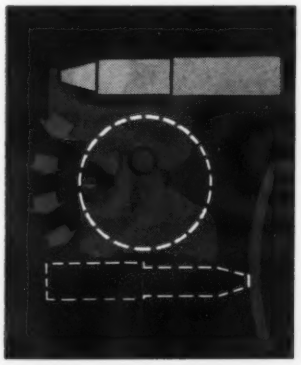

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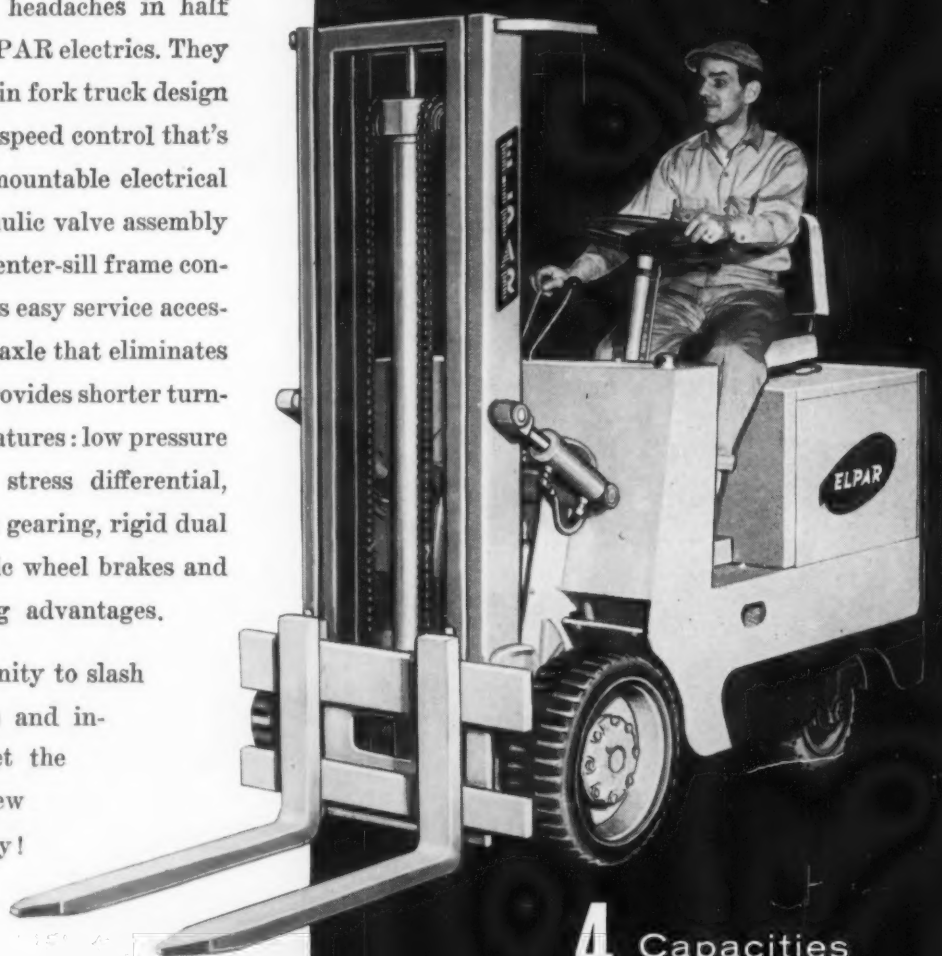

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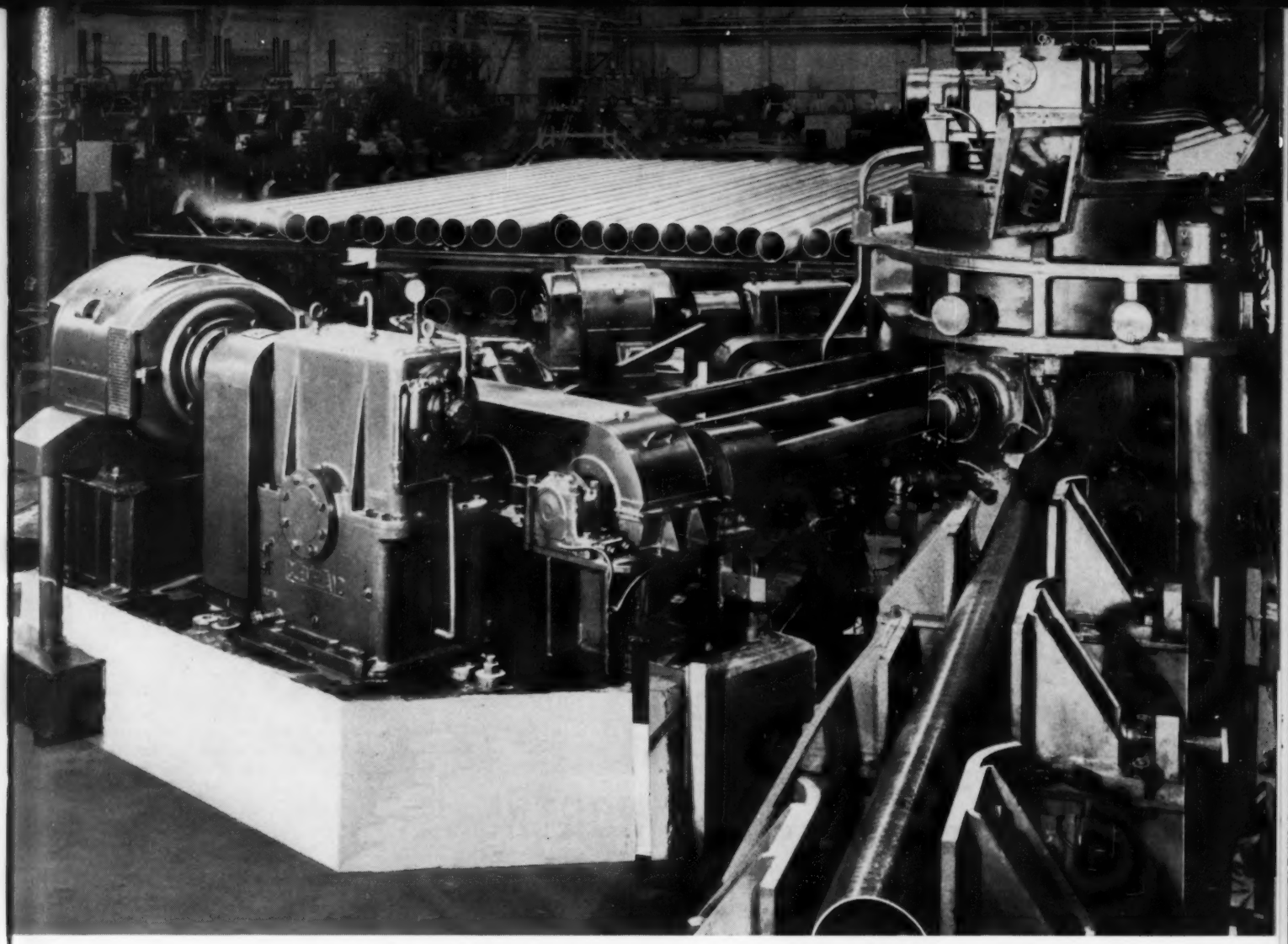

How to straighten the really big pipe!

One major Eastern steel producer has found the answer – the big Mack-Hemp Model A-5 Straightener shown above – the largest of its type in the world!

This A-5 takes really big bowed pipe from the sizing mill, pulls it in through three pairs of opposed cross rolls and then spins it out straight and round to high tolerances in only a single pass.

This despite the fact that the steel pipe being straightened is 16-inch in diameter, fifty feet in length!

To do a job like this, of course, the massive 85-ton roll frame is a must, as are the heavy duty rolls, and the combined 200 HP motors used to drive all six of them. In its first year, this Mack-Hemp A-5 straightener has handled more than 200,000 tons of pipe.

If straightening pipe or tubing is your problem – any size, any alloy – consider doing it yourself. The men from Mack-Hemp will be glad to give you all the facts you'll want to know.

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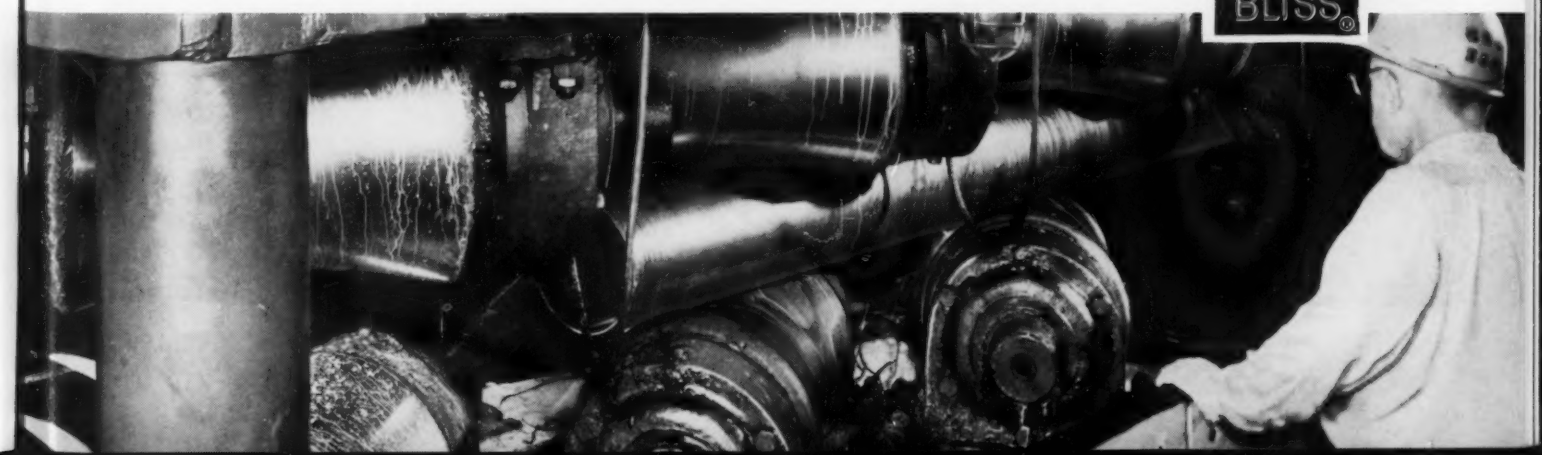

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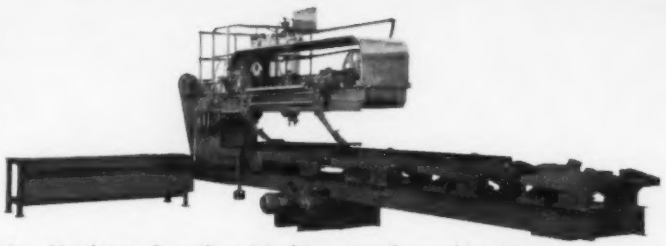
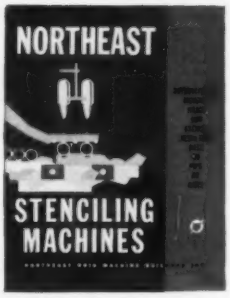


New Northeast Stenciling Machine stencils combinations of required information relative to size, length, class, weight per foot, ASTM or API specifications, date, tests and other pertinent data on double random, 21 ft 0 in. uniform, single random, black, galvanized, reamed and drifted, line, plain end, threaded and coupled pipe.

New NORTHEAST Stenciling Machine Saves Up To 75% On Pipe and Bar Marking!



If product identification and specification marking are a vital part of your production line, you will want to know more about our new stenciling machine that measures, weighs and stencils pipe from 2 in. to 16 in. OD automatically.

Write for Bulletin No. 360 that tells you in detail how marking can now be synchronized with your normal operating sequence to step-up production and reduce costs.

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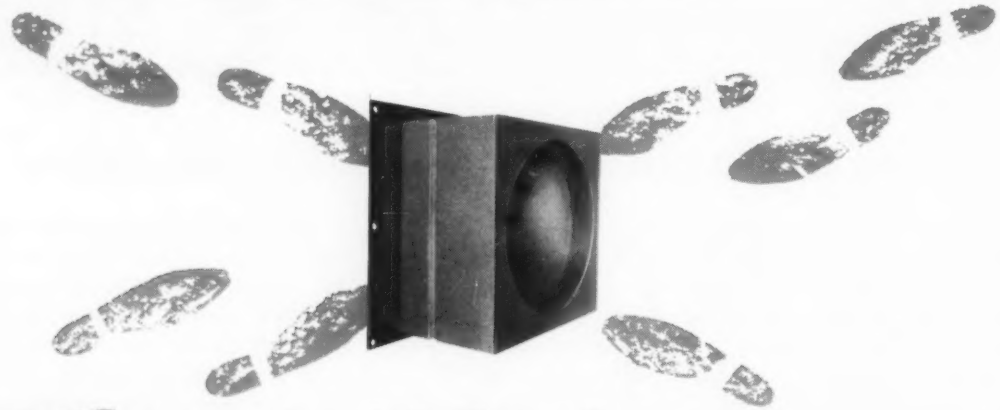

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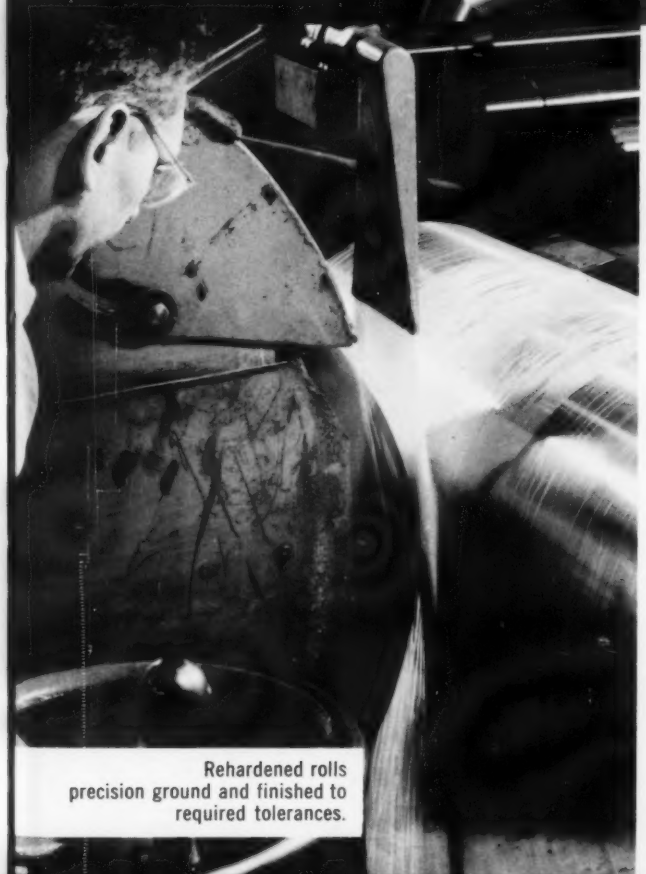

Rehardened rolls precision ground and finished to required tolerances.

Worn rolls being pre-tested with reflectoscope for surface and under-surface defects before hardening.

rehardened rolls

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TSP rehardening saves money by prolonging the life of the roll 2 to 3 times. Each rehardening is made at a fraction of the cost of a new roll.

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Write for Bulletin 158 "Important Facts About TSP Rehardening and Remaking of Cold Rolling Rolls."

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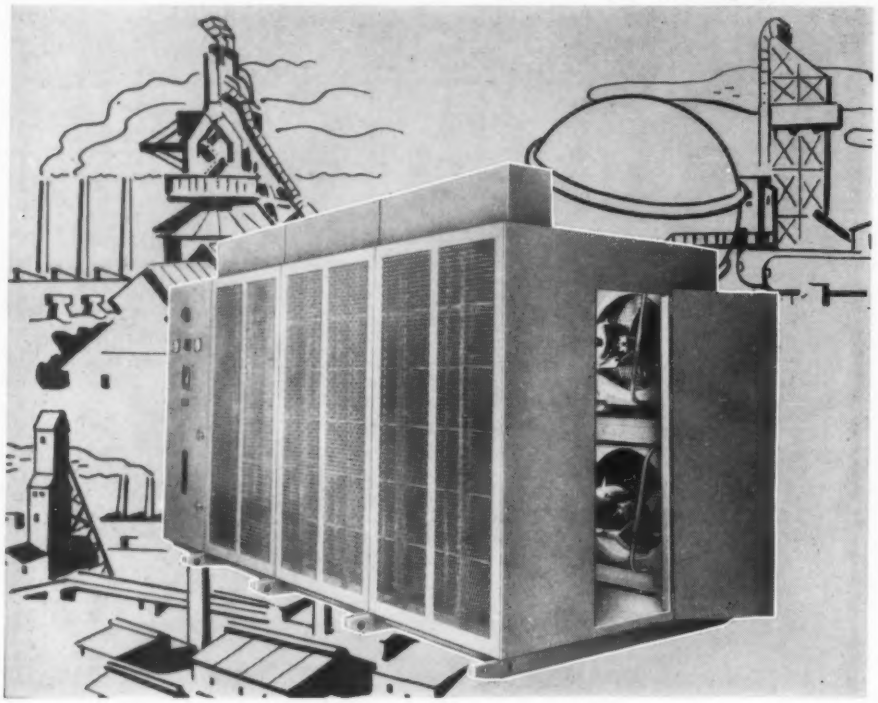

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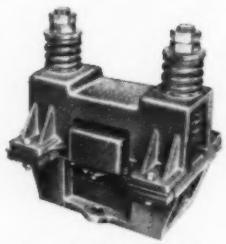

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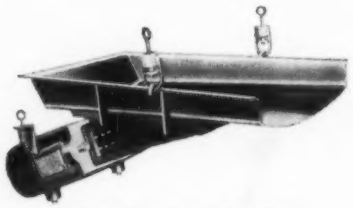

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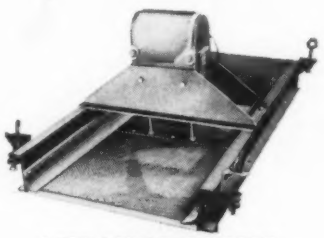

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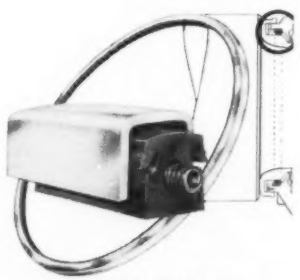

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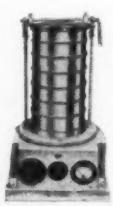

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Ohio Rolls

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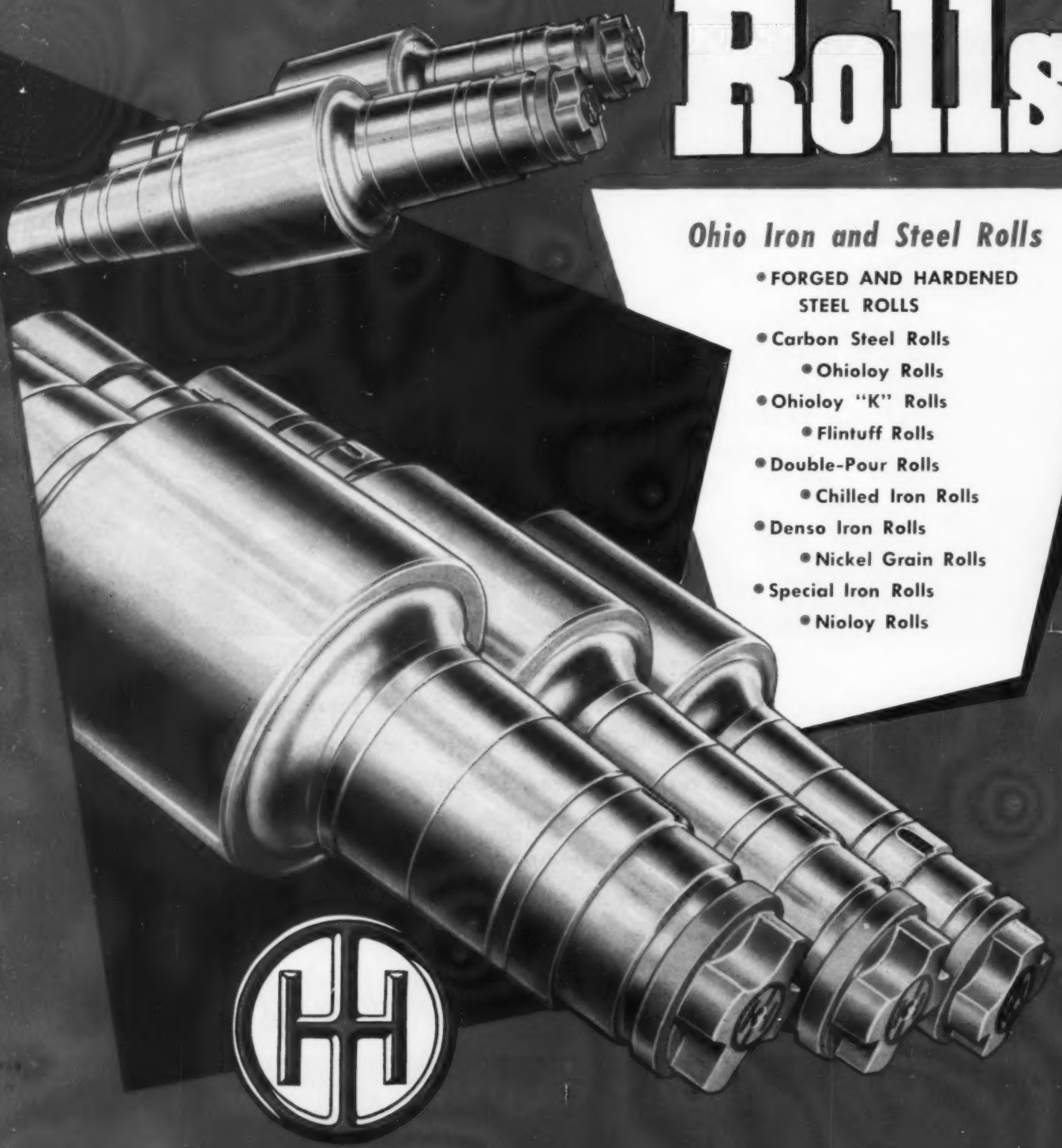

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ADDITIONAL IMPROVEMENT PROGRAM ANNOUNCED BY WHEELING STEEL FOR OHIO FACILITIES

△ Wheeling Steel Corp. has announced an $8,000,000 improvement program for its plants and facilities in Ohio. This represents improvements planned for 1960 and is in addition to the $5,700,000 program previously announced for plants and facilities in West Virginia.

One of the five blast furnaces at the Steubenville Works will be rebuilt and enlarged. It is estimated that the furnace's production capacity will be increased from the present 850 tons of pig iron per day to 1150 tons. The cost of this project is estimated at $2.7 million.

In order to meet the increased blowing engine capacity which will be required, the company plans a $1,500,000 turboblower installation.

Work is already in progress at the Steubenville Works on an oxygen pipeline from the South division to the North division. Construction of this large-diameter line and other preparatory work for the new oxygen generating plant at the South division are expected to cost over a million dollars.

The $6,000,000 oxygen plant, now under construction at Mingo Junction, Ohio, is expected to be in operation in the fall. The plant is being constructed and will be operated by the Mingo Oxygen Co.

The Bessemer converters at the Steubenville Works are being altered to permit blowing with a mixture of steam and oxygen instead of atmospheric air. The purpose of this change is to produce a low nitrogen steel (open hearth grade) with a wider range of application than the regular air blown steel.

The change in the steelmaking process at Steubenville South and improvements in open hearth practice at Steubenville North are expected to increase Wheeling's rated annual steelmaking capacity to about 2.5 million tons from the present 2.4 million tons.

Wheeling will also spend $1,500,000 on new soaking pits and necessary railroad track changes at the Steubenville Works. This will provide additional and more effective steel ingot heating capacity, permitting improved operations at the Steubenville plant's 66-in. hot strip mill.

At the Yorkville Works, recoilers are being installed on an electrolytic tinning line to meet the growing market demand for tinplate in coils. The cost of this project is estimated at $900,000. Recoilers were installed on one electrolytic tinning line at Yorkville in 1957.

STEELMEN TOUR ALLEGHENY LUDLUM PLANT

Pictured viewing the 2000 ton forging press operation during a recent tour of Allegheny Ludlum Steel Corp.'s Dunkirk Works are left to right: James Trabits, Dunkirk Works Engineer; Norman Stroth, Secretary of the AISE Buffalo Section; Ralph Hindson of the Steel Co. of Canada, and Buffalo Section Chairman; and Emil Kern, vice president of engineering, Allegheny Ludlum.

ALAN WOOD ORDERS EQUIPMENT FROM I-T-E

△ An order for silicon rectification and switchgear equipment has been placed with I-T-E Circuit Breaker Co., by Alan Wood Steel Co. as part of the first step in its projected 10-year expansion program at Conshohocken, Pa.

The new electrical facilities to be installed in a new substation at Conshohocken initially will provide additional power for a new 40-in. slabbing mill and 110-in. plate mill.

The rectifier—first I-T-E Unitron type unit to be built for steel mill use—will supply 1000 kilowatts, 4000 amperes at 250 volts, to a direct current loop system in parallel with an existing mercury-arc rectifier.

The rectifier will incorporate high-speed fault protection and special means for coordination with the existing rectifier. Cooling will be

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BLAST FURNACE

Super #3000 pumped into voids in lining in order to eliminate hot spots. Customer says Super #3000 works better in pump than any materials previously used (pumped higher than 200 feet). Sets quickly in void. Excellent patch.

USE SUPER #3000 AS A GENERAL PURPOSE BONDING AND PATCHING MORTAR. IT'S THE LOWEST PRICE INSURANCE YOU CAN BUY.

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provided for by a water-to-air heat exchanger which will supply substation building heat in the winter.

The metalclad switchgear includes 20 frames of indoor 15-kilovolt, 500 mva interrupting capacity air magnetic circuit breakers. Incoming power to the switchgear will feed at the outset from an existing 34.5-kv source, and in the future from a new 138-kv source.

The 250-volt d-c loop system will be protected by I-T-E type FB high-speed current-limiting breakers, consisting of a 6000-ampere single-pole unit and three 4000-ampere two-pole units.

Auxiliary equipment to be supplied includes a duplex console control center, with meters and switches; metering panels; synchroscope cabinet; utility metering compartments and a coordinated reactor synchronizing system. The duplex control desk will be located in a central dispatcher's office in the substation.

COMPLETE COPPER ROD MILL FOR SPANISH FIRM

△ A copper rod mill, constructed by Schloemann Aktiengesellschaft, Düsseldorf, was recently put into operation at SECEM (Sociedad Espanola de Construcciones Electro-Mecánicas, Córdoba, Spain).

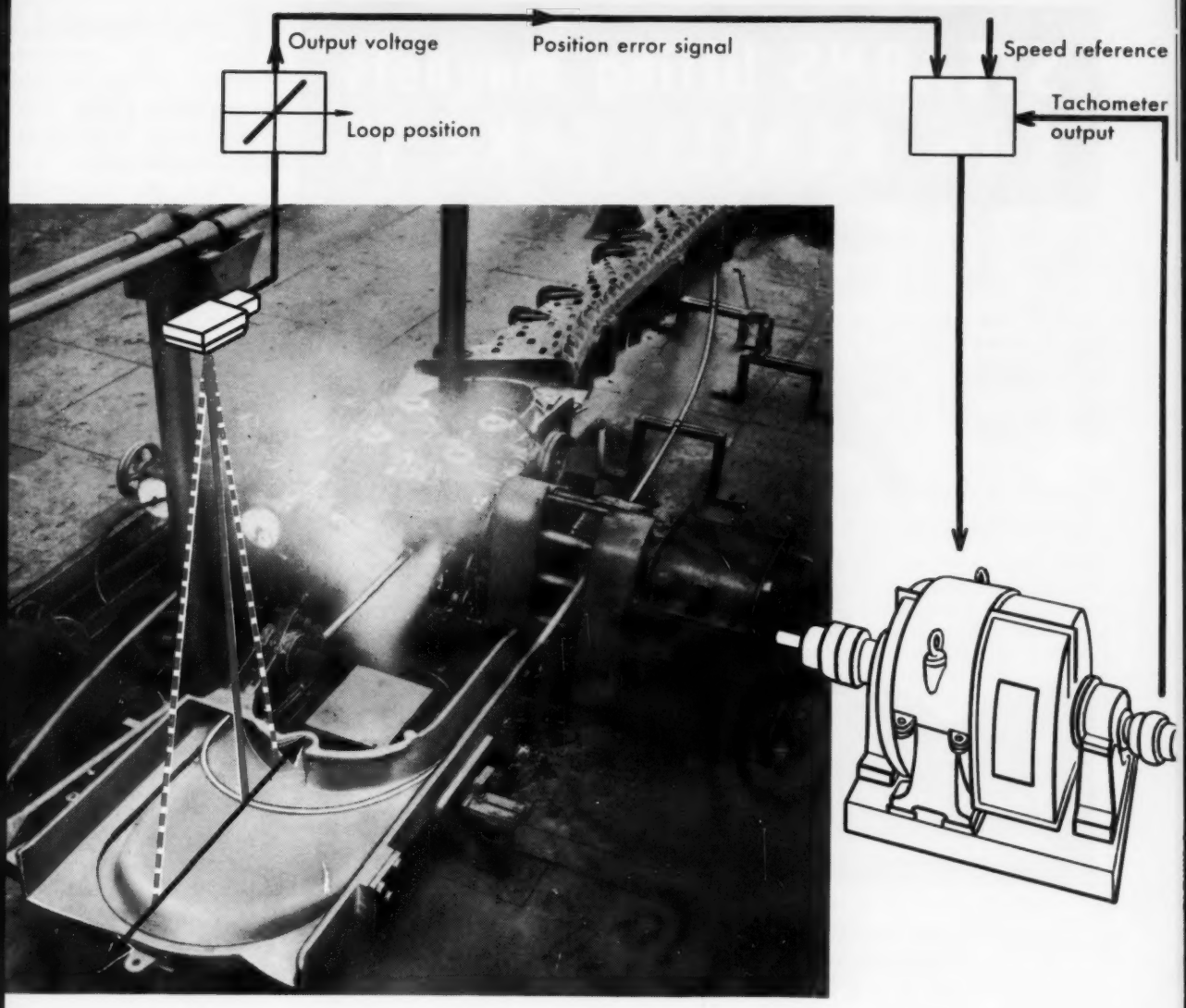
The plant consists of a three-high roughing stand with tilting table and tilting walls, a three-stand three-high intermediate train and an eight-stand finishing train. Automatic repeaters have been incorporated in the intermediate and finishing trains, to provide for a wide measure of continuous production. Rotary shears to crop the material are arranged between the groups of stands.

ENTRY INTO NEW FIELD ANNOUNCED BY RUST

△ Rust Furnace Co., engineers and constructors of industrial heating furnaces for more than 30 years, has entered into the field of designing, marketing and erecting electric soaking pits and reheating furnaces under the trade name of ELPIT, according to S. M. Rust, Jr., chairman of the board.

Rust has acquired the exclusive license to sell and erect the ELPIT

Photo-electric continuous loop regulator for rolling mills



It looks at the rod but doesn't touch it!

Without any time delay
it gives the position error signal
essential for
continuous loop regulation.

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- **Cooler Operating** — deep-ribbed case.
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Standard circular or rectangular magnets are available in either bolted or all-welded styles, in a wide range of capacities and sizes:

Circular — 20" to 77" dia.
Rectangular — 9" x 24" to 26" x 80"

Whatever your steel-handling problem, Stearns engineers have the answer with built-in value.

Call in your local Stearns representative for a job-studied recommendation and price quotation, or write for Bulletin No. 35-C-J.

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in the United States, Canada and Mexico by agreement with Ingenior Gunnar Schjelderup, Industriovner of Oslo, Norway, heretofore the sole designer and builder of this equipment.

Over 50 successful installations have already been made in Brazil, Denmark, Finland, France, Germany, Great Britain, Italy, Norway, Sweden and Switzerland.

The ELPIT consists essentially of a well-insulated steel casing, without flues or stacks, resting on a simple concrete foundation. Electrodes through the end walls connect with heating elements which consist of carborundum troughs filled with coke. Energy is transmitted mainly by radiation resulting in highly uniform heating. The ELPIT is provided with semi- or full - automatic temperature and power controls.

The ELPIT is designed to suit local conditions such as available space and size of charge and can be of almost any rectangular shape.

Two notable features of the ELPIT are its economy from the standpoint of installation and its quality heating from an operative standpoint. The method of heating can provide any degree of scale formation and it is possible to hold scale formation to a fraction of one per cent.

It does not need such auxiliary equipment as recuperators, chimney, flues, control valves and slag pits. Its efficiency of operation is high because of having no flues or openings to cause heat losses. Maintenance and repair costs are low because it lacks the numerous pieces of auxiliary equipment of the fuel-fired pit.

In the manufacture of high-quality steel where rigid control is essential the ELPIT is a valuable auxiliary soaking pit when used in conjunction with a conventional gas or oil-fired pit.

BEGIN CONSTRUCTION ON PLATE HEAT TREAT LINE

△ Construction has started on the new plate heat treating line at the Homestead District Works of U.S. Steel Corp. This new line is the second to be designed and installed at this plant by the Drever Co. While no larger than the first, the line can provide greater pro-

NEW LINK-BELT WORM GEAR SPEED REDUCERS

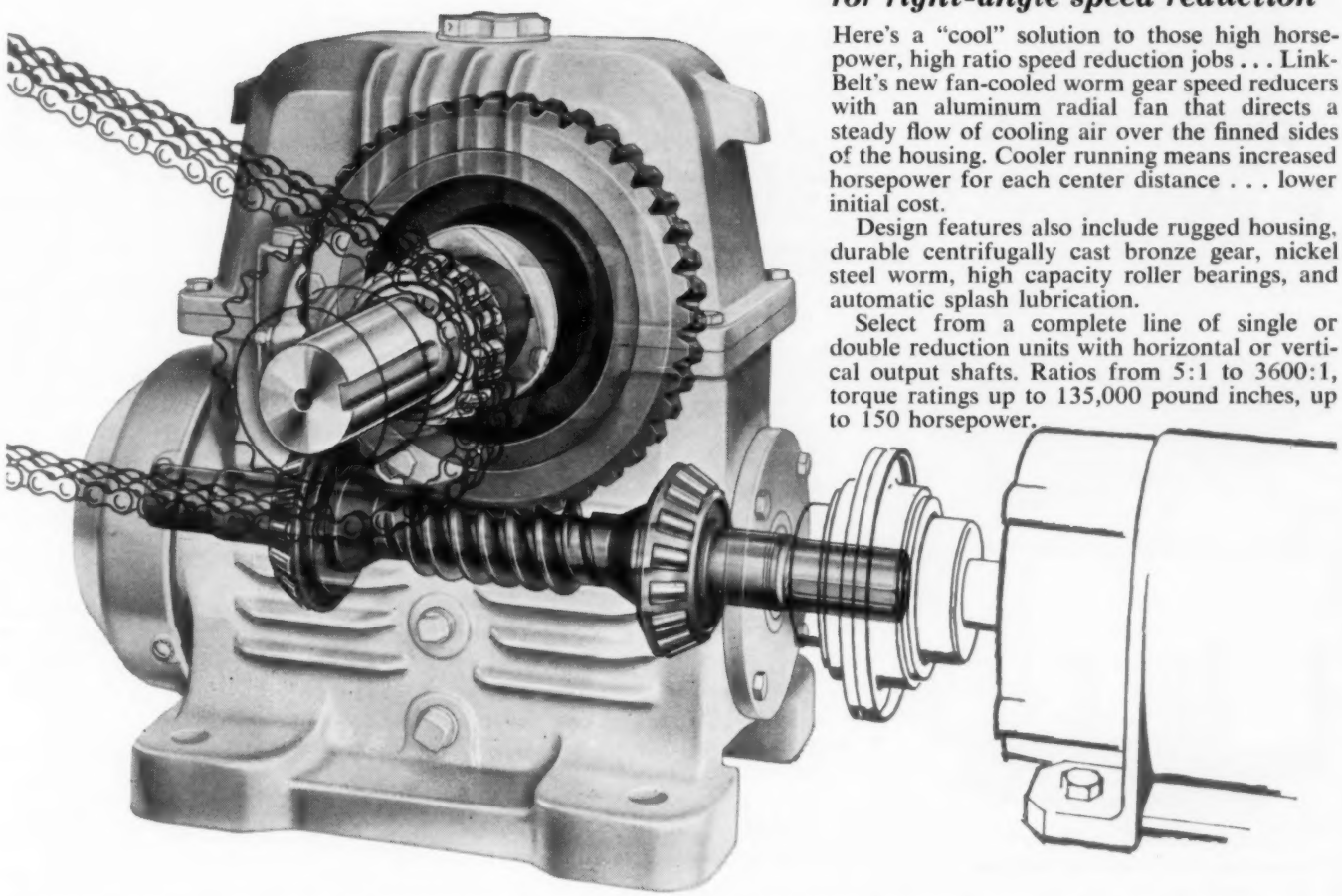
fan-cooled high capacity compact

Industry's most complete line for right-angle speed reduction

Here's a "cool" solution to those high horsepower, high ratio speed reduction jobs . . . Link-Belt's new fan-cooled worm gear speed reducers with an aluminum radial fan that directs a steady flow of cooling air over the finned sides of the housing. Cooler running means increased horsepower for each center distance . . . lower initial cost.

Design features also include rugged housing, durable centrifugally cast bronze gear, nickel steel worm, high capacity roller bearings, and automatic splash lubrication.

Select from a complete line of single or double reduction units with horizontal or vertical output shafts. Ratios from 5:1 to 3600:1, torque ratings up to 135,000 pound inches, up to 150 horsepower.



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on Link-Belt's comprehensive line of speed reducers—contact your nearest Link-Belt office or authorized stock-carrying distributor . . . or check and send this coupon to Link-Belt Company for data on all or any combination of the following:

- ☐ gearmotors—Catalog 2747
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- ☐ universal worm gear speed reducers—Catalog 2724
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duction of heat treated plate due to greater flexibility provided for handling plate and from improved combustion design.

The line, built to process plate up to 45 ft long x 156 in. wide, and 2 in. thick, will consist of a hardening furnace, a tempering furnace and a pressure quench. The hardening furnace will have a maximum temperature rating of 1750 F and will be about 18 ft wide and 142 ft long. It will handle 18 tons per hour with an average hearth load of 90 per cent.

The tempering furnace, also 18 ft wide, and 160 ft long will provide a maximum temperature of 1350 F and can process 22 tons per hour.

Located to receive plate from either the hardening furnace, the tempering furnace or the previously installed stainless plate furnace, the quench utilizes water sprays combined with a platen press. This press keeps the plate flat during quenching. It will have an area of 164 in. x 48 ft with a pressure of 100 tons. Quench water is delivered at the rate of 21,000 gpm through 34,632 holes.

The continuous heat treating line will be under the control of a single operator located in a room overlooking the line, with complete "pushbutton" control and with television monitoring. It is expected to be in operation later this year.

Construction of another Drever continuous plate heat treating line at this plant is going ahead at the same time. This new line will treat plate from the 100 in. plate mill.

PITTSBURGH STEEL TO STRENGTHEN ORE SUPPLY

△ The largest single raw material program in the 58-year history of Pittsburgh Steel Co. was announced recently by president Allison R Maxwell, Jr. A three-phased project, it includes two immediate steps to strengthen Pittsburgh Steel's iron ore supply.

The third phase was announced in St. John's, Newfoundland, by Premier Joseph R. Smallwood. It consists of Pittsburgh Steel's option on part ownership of a big, new open-pit Canadian ore property. The arrangement is designed to start delivering iron ore concentrates to Pittsburgh Steel in approximately five years.

In recent years, as little as 23 per cent of Pittsburgh Steel's iron ore requirements came from partnership mines. A year ago, the company moved to increase this to 40 per cent. The remainder is supplied at higher costs through contract and open market purchases.

As a result of the newest program, approximately 70 per cent of Pittsburgh Steel's annual iron ore requirements will be supplied by mines in which the company has ownership interests.

The third phase will involve Pittsburgh Steel's expenditure of $6,000,000 in different amounts over the next five years.

These are the three phases of the program:

I. *Present to 1963*—Pittsburgh Steel has become sole owner of all stock in the Bennett Mining Co., Keewatin, Minn., an open-pit Mesabi Range producer since 1917. This will give Pittsburgh Steel up to 500,000 tons of ore per year over the life of the property.

II. *Present to 1965*—Pittsburgh

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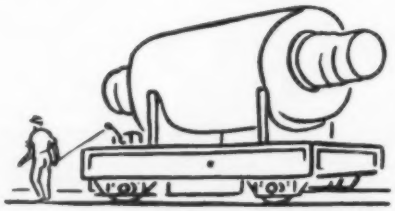
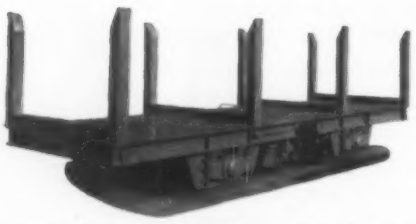


20-Ton Storage Battery with Cradle for Pipe



40-Ton Safety-Type Walk-Along with Stake Bed

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- *SAFE — because one lever controls forward-reverse-stop.*
- *SAFE — because car stops when operator releases lever.*

Atlas transfer equipment is designed for your specific load and production needs. Optional power includes Storage Battery (Walk-Along or Rider-Type) • Gas-Electric • Diesel-Electric • Cable Reel AC • Cable Reel DC • Cable Reel AC With Fluid Coupling • also remotely controlled cars without trailing cable.

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"You can catch more flies with honey than you can with vinegar"--is an old, familiar truism that was popular back in grandpa's day. And, it is just as true in this jet-propelled atomic age of today as it ever was in those bygone, horse-and-buggy days when it was first written.

From the beginning it has been the policy of this company to be genuinely friendly with everybody--customers and suppliers alike. It's a policy that has won this company a host of good friends--and helped keep them, year after year.

For bearings--any type, any size, any brand--dial the number below. You'll get *immediate* delivery, day or night. Not only that but--you will get the kind of friendly service that will make **YOU** smile with pleasure, too. Try it!

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Steel has acquired a 25 per cent interest in the Lake Mining Co. of Biwabik, Minn. This producer of open-pit Mesabi ores, is being reorganized to accommodate Pittsburgh Steel's entry. A maximum of about 250,000 annual tons of ore will be added to Pittsburgh Steel's supply through 1965.

III. *After 1965*—Pittsburgh Steel has joined a group of American and Canadian ore-mining and steel companies who have formed Wabush Iron Co. Limited. Wabush has already begun development of a five-square mile ore deposit near Wabush Lake, 200 miles north of Seven Islands in Newfoundland and near the western border of Labrador.

Regarded as one of the largest homogeneous iron ore deposits in North America, the Wabush property has proved reserves of one-billion tons of low-grade ore readily concentratable to a high iron content ore.

Pittsburgh Steel does not now have a sintering plant capable of handling the ore tonnages it will receive from Wabush. However, the company is studying various designs and possible locations and expects to have a final decision soon. Preliminary estimates indicate the plant will cost between seven and nine million dollars.

PRODAC CONTROL SLATED FOR NEW STRIP MILL

"Prodac" positioning controls and electrical drive equipment will be supplied by Westinghouse Electric Corp. for the continuous roughing mill associated with the new 80-in. hot strip mill to be installed at Great Lakes Steel Corp., Division of National Steel Corp.

The continuous roughing train consists of a 1500-hp scale breaker and five roughing stands, two rated at 5000 hp each and three rated at 10,000 hp each. The controls designed by Westinghouse Systems Control Department, Buffalo, N.Y., will position the roughing mill screwdowns, edger adjustments and sideguards as well as the entry scale breaker.

The positioning controls will respond so rapidly to their commands that two slabs, each requiring different settings, can be processed at the same time through the roughing mills.

JOINT TEST COKE PLANT TO USE LOW-GRADE COAL

△ A research facility for the experimental production of metallurgical coke from noncoking subbituminous coal will be built near Kemmerer, Wyoming, and operated jointly by Food Machinery and Chemical Corp. and United States Steel Corp., according to an announcement made by officials of both companies.

United Engineers and Constructors will design, engineer and construct the facility. The test plant will have a designed capacity of 250 tons of coke per day and is scheduled for initial operation later this year. It will carry on further experimental work with a new process which has been developed and piloted over a period of years by FMC in an effort to make local industrial use of Wyoming low-grade coal.

The new coke process uses a

TITZEL

JIB CRANES

contribute to Production Efficiency in Steel Plants and Allied Industries

JONES & LAUGHLIN STEEL CORPORATION PHOTOGRAPH

FROM DESIGN TO INSTALLATION

- Jib and Casting Pit Cranes
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- Jib, Pillar, Wall and Floor Traveling Cranes
- Cover Cranes for Steel and Aluminum Plants
- Button and Skull Burning Cranes for Scrap Yards
- Stopper Rod Drying Ovens
- Hydraulic Descaling Systems
- Mill Scale Handling Systems
- Palm Oil Systems
- Mill Dust Handling Systems
- Pneumatic and Mechanical Conveyors
- Crushing Installations
- Designers and Manufacturers of Special Equipment

The Spout or Metal Runner Handling Crane shown above is one of the various types of Titzel Jib Cranes that was designed and built to meet a specific need. All Titzel Cranes installed provide smooth, safe, dependable operation and give consistently efficient, long-lasting performance. If you have a Crane problem of any kind Titzel Engineering will solve it for you. For complete information write or phone MUseum 1-9622.

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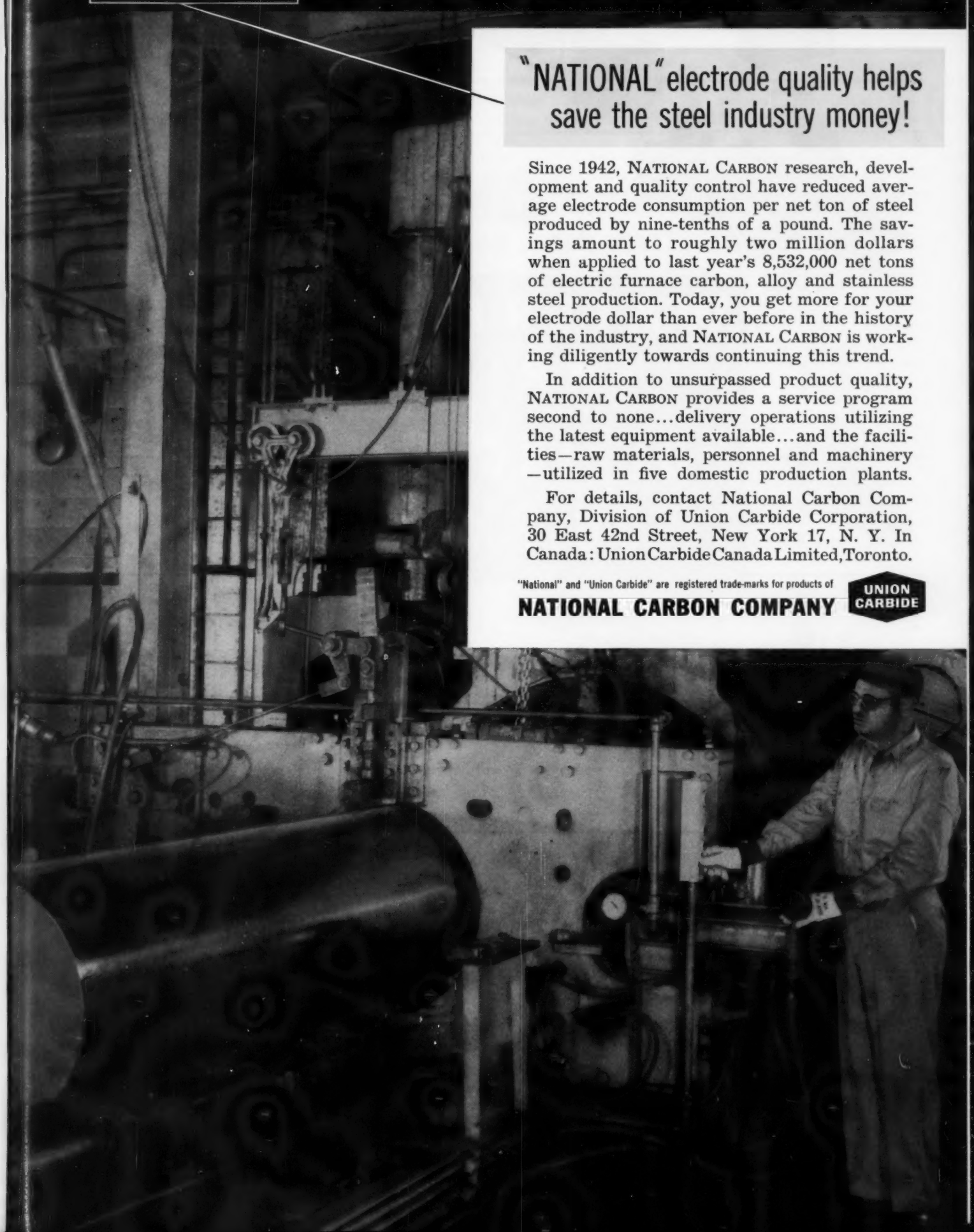

"NATIONAL" electrode quality helps save the steel industry money!

Since 1942, NATIONAL CARBON research, development and quality control have reduced average electrode consumption per net ton of steel produced by nine-tenths of a pound. The savings amount to roughly two million dollars when applied to last year's 8,532,000 net tons of electric furnace carbon, alloy and stainless steel production. Today, you get more for your electrode dollar than ever before in the history of the industry, and NATIONAL CARBON is working diligently towards continuing this trend.

In addition to unsurpassed product quality, NATIONAL CARBON provides a service program second to none...delivery operations utilizing the latest equipment available...and the facilities—raw materials, personnel and machinery—utilized in five domestic production plants.

For details, contact National Carbon Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

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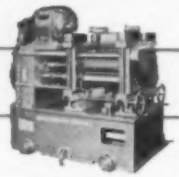
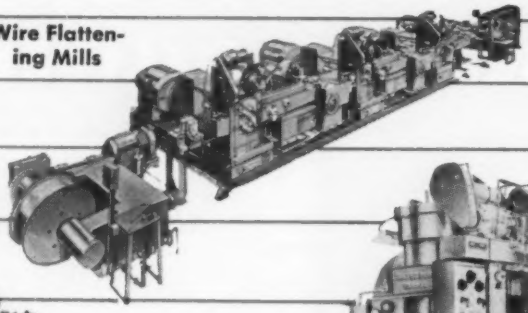
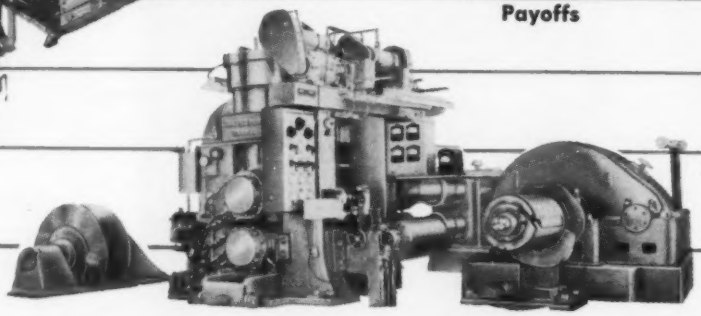


Coilers

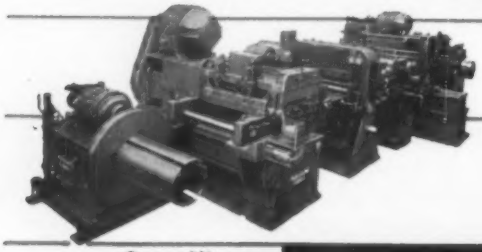


Wire Flattening Mills

Payoffs

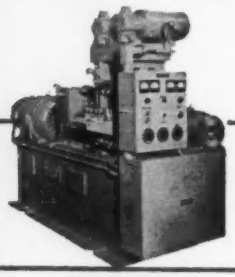


Two High Strip Rolling Mills

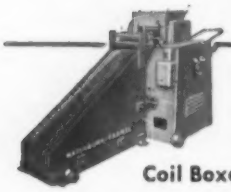


Gang Slitters

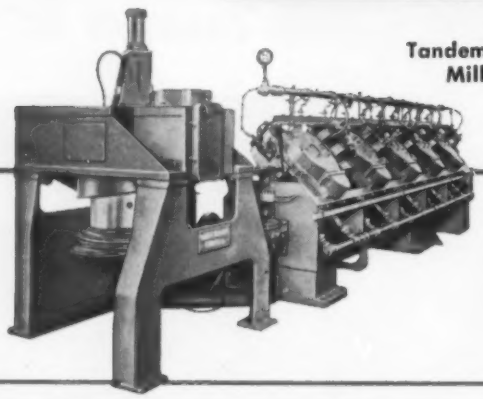
WATERBURY FARREL ROLLING MILL EQUIPMENT



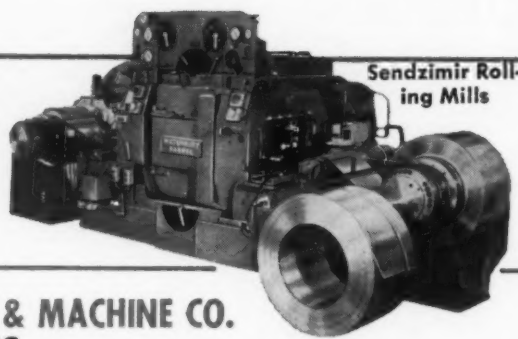
Four High Strip Rolling Mills



Coil Boxes



Tandem Rod Mills



Sendzimir Rolling Mills

ROLLING MILL EQUIPMENT

- Four-High Rolling Mills
- Gang Slitters
- Grading Mills
- Mint Mills
- Sendzimir Rolling Mills
- Special Rolling Mills
- Two-High Rolling Mills

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- Coilers
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- Three-High Rod Mills
- Two-High Rod Mills

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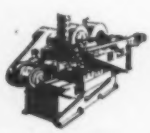
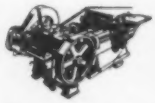
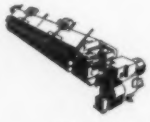


Cold Heading Machinery

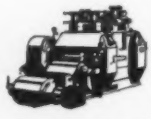


Power Presses

Rolling Mill Machinery



Wire Mill Equipment



Sendzimir Mills & Special Machinery

WF-31R

nonconventional approach to the conversion of coal and the production of coke from various grades of coal, including those hitherto considered unsuitable for coking. FMC's interest in this project was prompted by the need for an intermountain area source of coke for its elemental phosphorus plant in Pocatello, Idaho. Essentially all the coke required for this and other similar uses in the area is presently shipped from coke plants east of the Mississippi River.

The jointly owned facility will provide sufficient quantities of material to make large-scale tests in FMC'S phosphorus furnaces and for U. S. Steel to make initial tests to evaluate the use of the product in blast furnaces.

Officials of the two companies emphasized that this undertaking is the beginning of a period of research and development of this new form of coke for various applications in both the chemical and metallurgical field.

WORK PROGRESSING ON MCLOUTH SINTER PLANT

△ Output of sinter for charging two blast furnaces at the Trenton, Mich., works of McLouth Steel Corp. will be doubled with the erection of a second sinter plant now being constructed by Dravo Corp.

Dravo also is completing a contract for expansion of boiler house and pump facilities.

The new sinter plant will be a duplicate of the 2100-ton-a-day Dravo-Lurgi installation placed in operation last year at Trenton. Located at the south end of the works area, between the present sinter plant and a blast furnace dust thickener, the new plant will go into production this year.

Built principally for the agglomeration of Lake Superior ore fines too small for direct charging into blast furnaces, the plant also will be used to reclaim a five-year accumulation of flue dust with high iron content.

Core of the new sinter plant will be a continuous strand machine, 111½ ft long and 8¼ ft wide and consisting of 77 cast iron pallets. The suction area over its 13 windboxes will be about 700 sq ft. Speed of the strand will vary from 6½ ft to 17 fpm as desired.

The cooler, which will be about 137 ft long, will lower the temperature of sintered material from 1450 F to 235 degrees. At the lower heat level, material may be transported on rubber belt conveyors without damaging the belt.

Processing raw materials and sinter will also necessitate a variety of storage and mixing bins, pug mills, rod mills, balling drums and sinter dust collectors.

Work on the plant's boiler house involved installation of a 120,000 lb/hr superheated steam high pressure boiler with piping and associated equipment to handle increased steam demands from turbines supplying air to enlarged blast furnaces. This new unit is the fifth of the same size at Trenton.

In expanding the pump house facilities, a 36-ft x 63-ft brick and steel structure was erected, resting on a concrete foundation constructed inside a permanent single-skin steel sheet pile cofferdam. A water intake, bar screens and traveling water screens are built into the substructure.

How to cut mill downtime due to bearing failures...

use A·B·K* bearings

Roll neck and slipper bearings made of A-B-K material often outwear metal bearings many times. Their ability to cushion impact loads without peening, scoring or heat-checking protects roller necks, housings and chucks. Simplicity of design and light weight speed installation. Can be lubricated with grease, oil or water *alone.* Ask our engineers to help you solve your specific problems.

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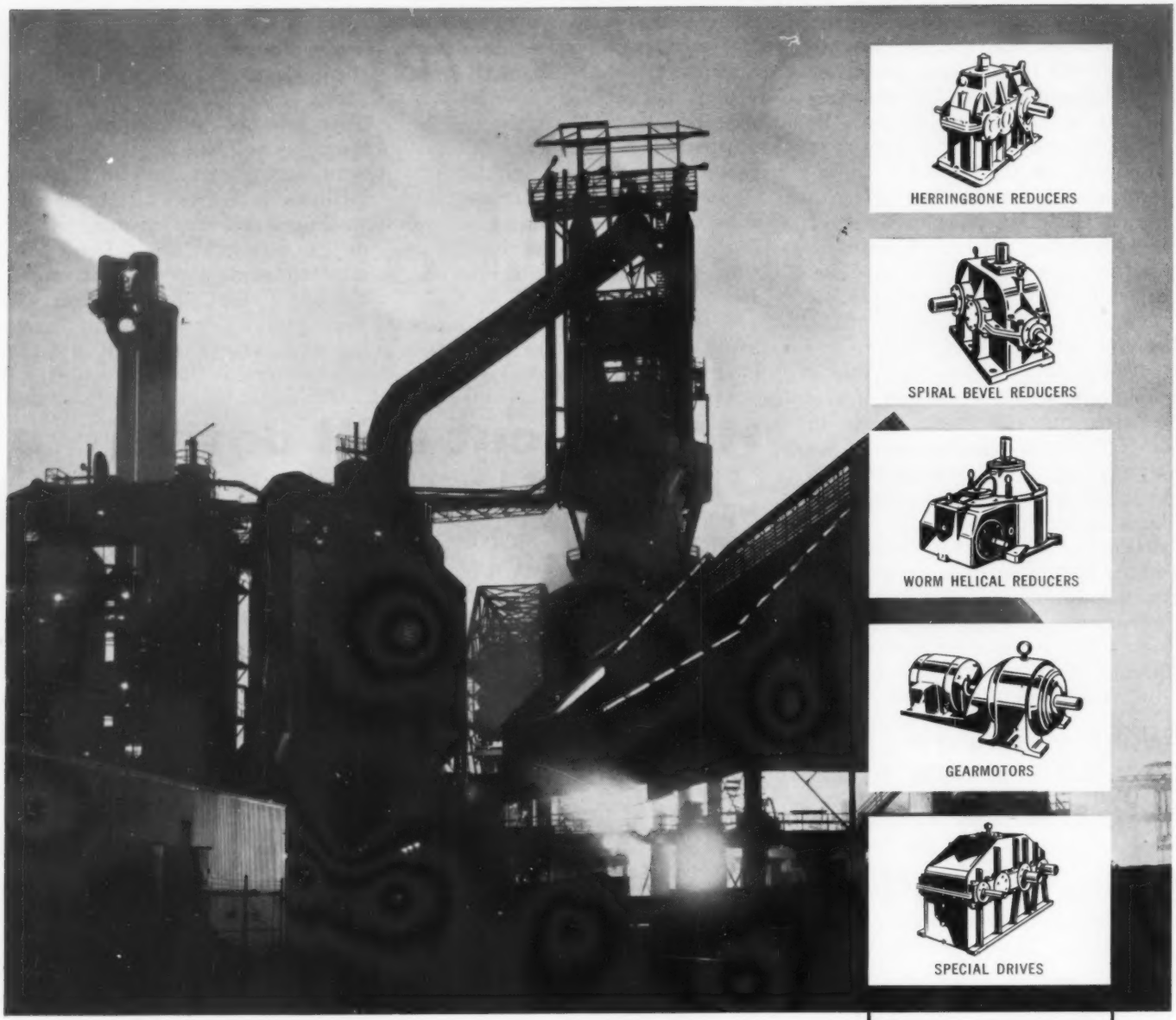

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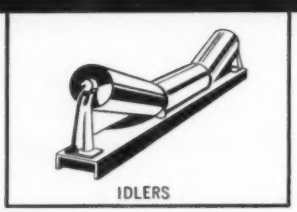
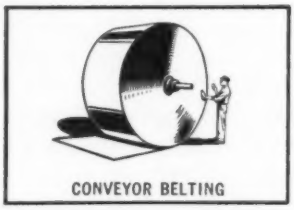
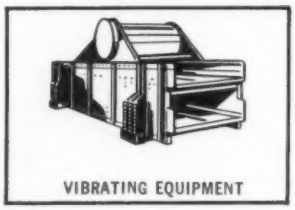

IDLERS


CONVEYOR BELTING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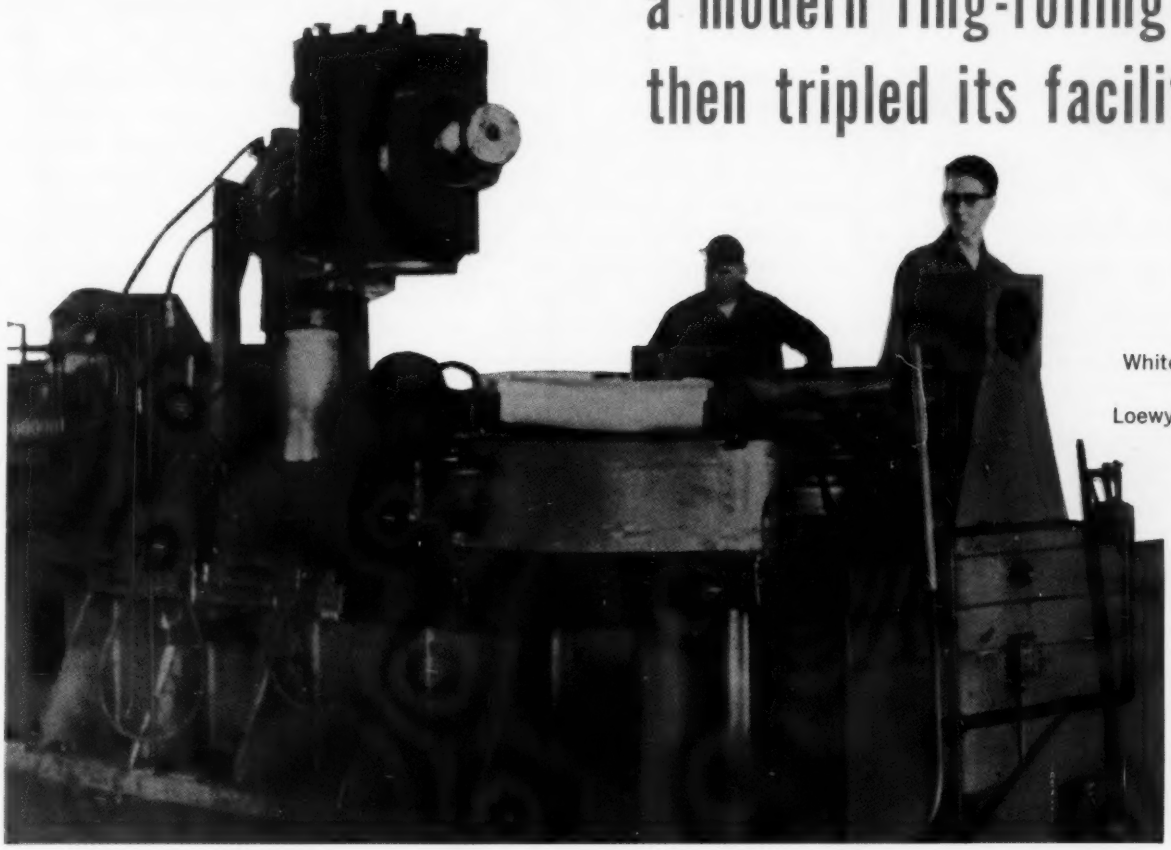
One good "turn-key" deserves another...

Loewy built and equipped a modern ring-rolling plant, then tripled its facilities



White-hot jet engine ring on a Loewy ring-rolling mill

When the Navy needed rings to a number of unusual specifications for jet planes, a major supplier called upon Loewy-Hydropress to design and build a complete new ring-rolling plant and initiate production. Loewy developed several metal-forming methods, built the basic machinery, designed, constructed and equipped the plant, supplied the complete installation, organized the material flow, and put the plant into operation. Demand for the products quickly exceeded expectations and Loewy was commissioned the following year to triple the size and facilities.

In carrying out what amounted to two "turn-key" jobs, Loewy faced a number of challenging tasks. Navy specifications called for profile rings of alloy steels, stainless steels and titanium up to 72 in. in diameter and 9 in. high. Extruded bar stock and centrifugal castings were to be the basic materials. With these requirements as the goal, Loewy went to work.

Process engineering was confronted with problems not met before, but Loewy metallurgists, together with heat-treating and rolling mill specialists, solved them all, designing the installations to difficult requirements.

It was also Loewy's task to find the best location for the plant. The site chosen, despite its advantages, presented certain physical obstacles, such as streams which had to be diverted or channeled underground. While machinery and auxiliaries were being built, the building and equipment foundations, designed by Loewy, were poured, and the structure rose.

Latest type machinery was then installed for bending, resistance welding, blank heating, annealing, heat treating, ring rolling, expanding, shrinking, shotblasting and machining. Intricate ventilation and fire-protection systems were installed. The most modern quality-control and metallurgical equipment were integrated into the system.

All deadlines were met. Both the initial plant and the vastly expanded facilities went into production on schedule.

If the swift march of technological progress and the pressure of competition urge you to make new products by new processes—in any industrial facility, large or small—take into account what Loewy can do for you. Contact Dept. C-4.

The initial ring-rolling plant

The expanded plant

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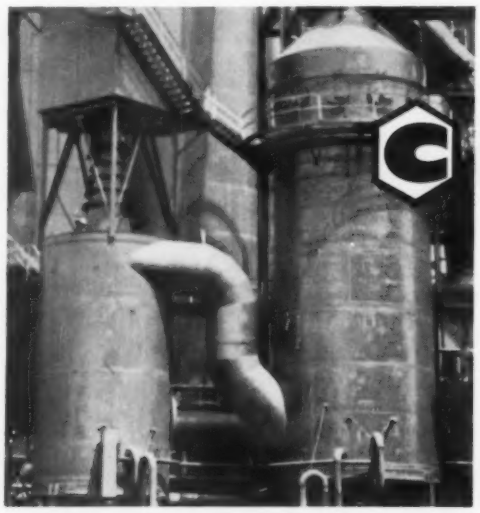
Thirty-six Chemico Venturi blast furnace washers are now in successful operation or on order for 20 separate steel plants. Other units are setting new gas cleaning performance standards on oxygen steel converters, open hearth furnaces and gray iron cupolas.

Contact Chemico if you are looking for top performance gas cleaning in your steel plant operation.

at right is a photo of
a Chemico Venturi gas washer
and cooling tower
at work on a blast furnace.



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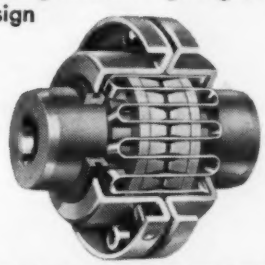
How one FALK coupling saved more than $1,000 per month

Pictured below is a Falk Steelflex Coupling assembly which connects a 2500 hp motor to a reduction unit driving an 18″ bar mill in a Midwestern steel plant. This coupling replaced another type which broke repeatedly, causing maintenance expense averaging $1,000 a month—plus costly production losses. Since installation of the Falk Coupling, with its controlled torque mechanism that disengages when a predetermined overload occurs, there has been no interruption of production. Savings in maintenance and in lost production time are well in excess of $1,000 per month...dramatic proof of the importance of coupling design!

Long coupling life is not the sole criterion of coupling performance. Inadequate shaft couplings may be the cause of bearing damage or shaft breakage on your machines. If so, a change to Falk Steelflex will give two-fold protection to your connected machines: (1) compensation for reasonable degrees of shaft misalignment, and (2) torsional resiliency to reduce peak loads as much as 30%. These advantages are as important to you as the long service life of the Falk Steelflex Coupling itself.

Falk Steelflex Couplings, in types and sizes to meet virtually all industrial applications, are promptly available from distributor, warehouse and factory stocks. Consult your Falk Representative or Authorized Falk Distributor.

Basic **Type F**—cutaway view showing exclusive grid-groove design



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...a truly flexible coupling

Here is the coupling that has all the strength of steel, yet is truly flexible. *More than a million* have been bought for industrial service of many kinds.

Because, in addition to its inherent superiorities of design, the Type F Steelflex can be used horizontally or vertically without modification or special parts, it has been adopted as standard in many plants—and by many designers and manufacturers of industrial equipment...Write for Bulletin 4100.

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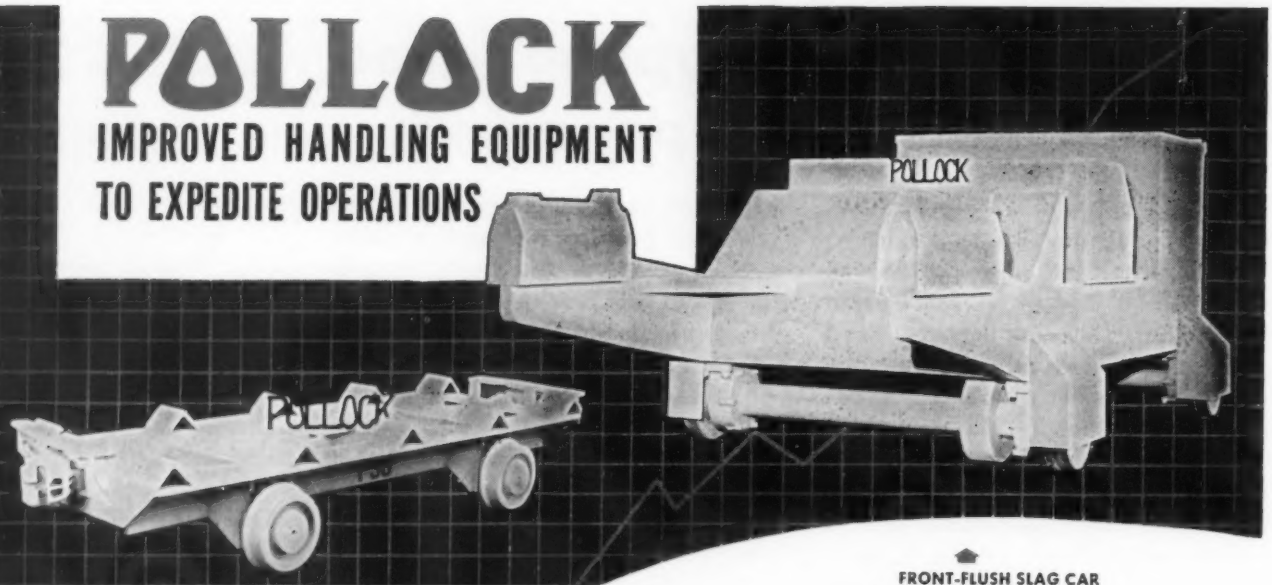
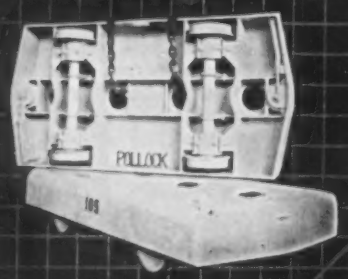


FRONT-FLUSH SLAG CAR

CHARGING BOX CAR



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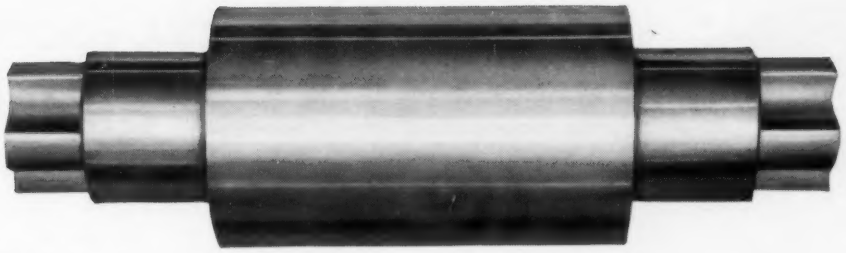

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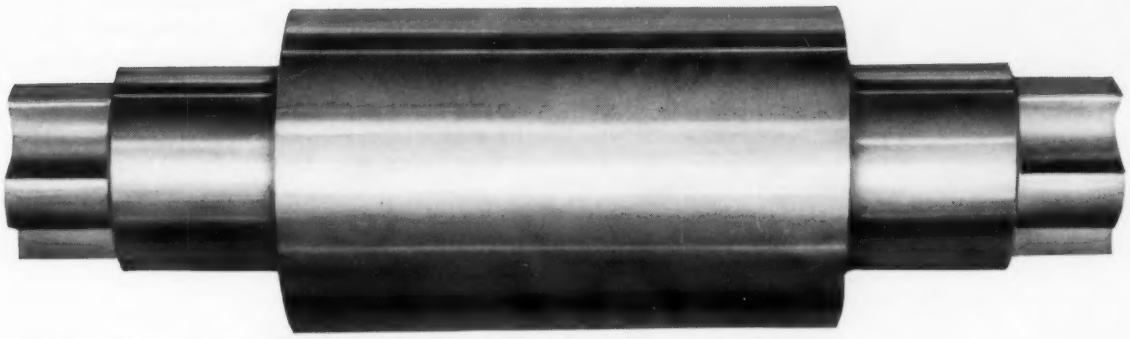

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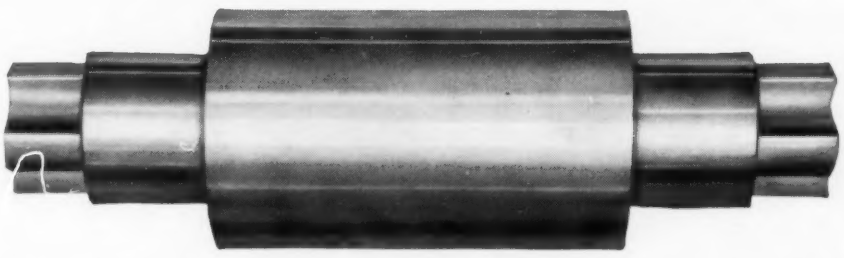

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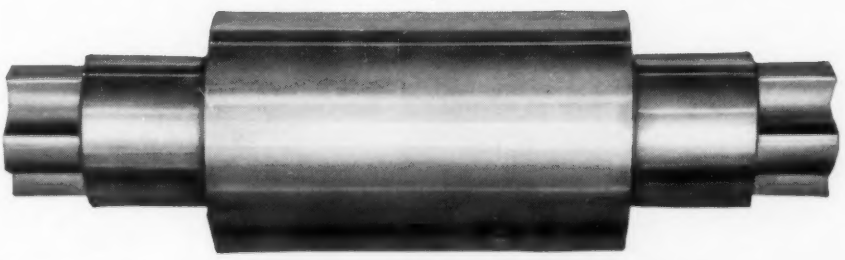

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BETHLEHEM FORGED ROLLS

for cold-rolling steel sheet, strip and tinplate, and non-ferrous metals

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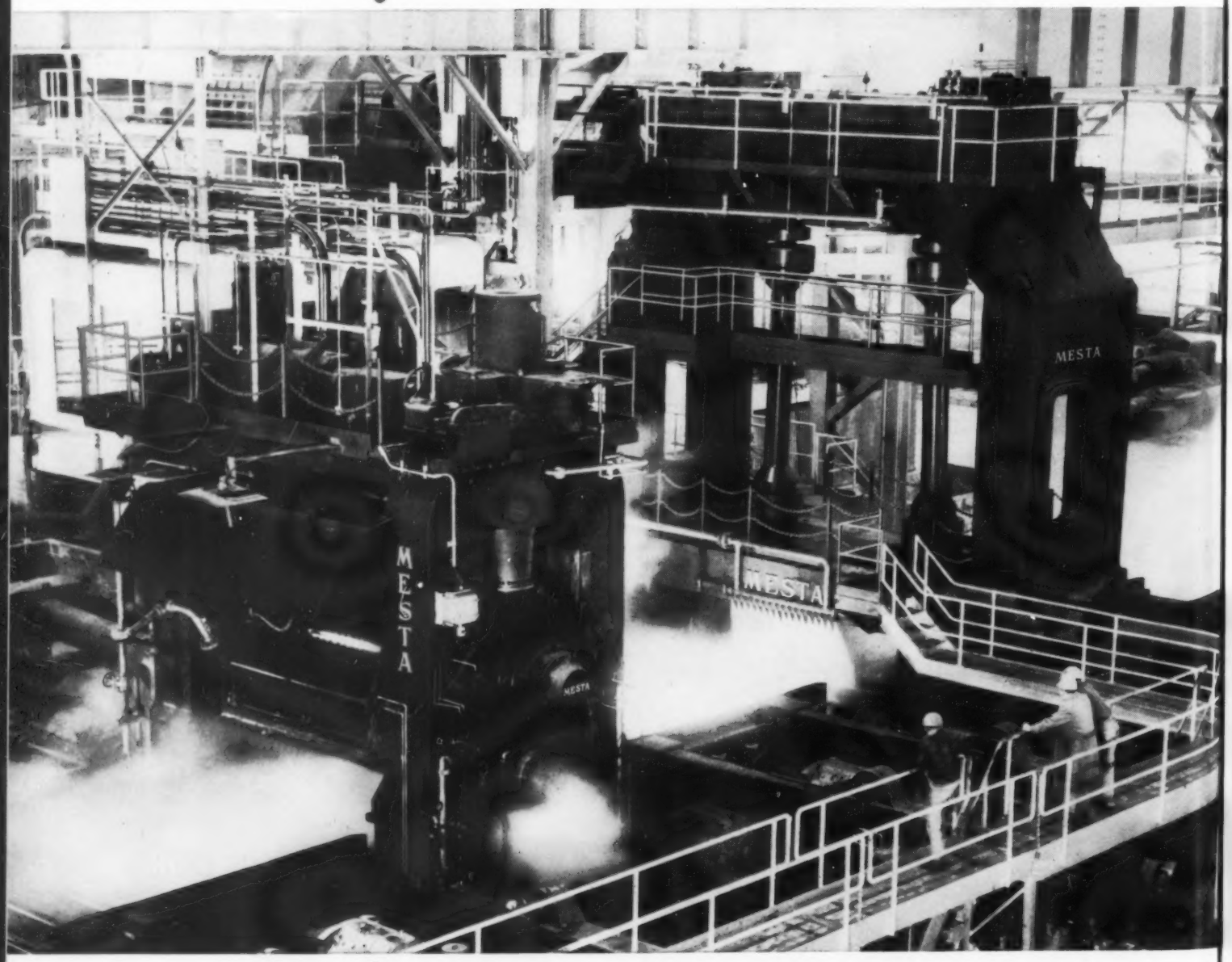
MESTA

FOUR-HIGH REVERSING MILL and VERTICAL EDGING MILL for SLABS and PLATES

At Lukens Steel Company, the 140″ Four-High Reversing Plate Mill and Vertical Edging Mill is an unusual installation. Although this mill is operating primarily as a slabbing mill to reduce ingots into slabs for rolling plates on other mills, it can complete the rolling of plates to finished sizes directly. The Vertical Edging Mill, largest ever used in tandem with a Plate Mill in this country, provides edge rolling of the ingot which remains in the horizontal position during the complete operation. This installation is the major unit which will increase the plate rolling capacity at Lukens by 40 per cent.



Designers and Builders of Complete Steel Plants

MESTA MACHINE COMPANY

PITTSBURGH, PENNSYLVANIA

Personnel News...

J. Leonard Hough has been appointed chief engineer of Republic Steel Corp.'s Youngstown, Ohio, steel plant. Mr. Hough, formerly assistant chief engineer, succeeds **John Stouffer** who retired recently. A veteran of more than 20 years in the industry, Mr. Hough was associated with U. S. Steel, Koppers Co. and Algoma Steel before joining Republic.

Frank S. Wilkins has been appointed superintendent of the Rod and Wire Department at the Aliquippa Works of Jones & Laughlin Steel Corp. Mr. Wilkins, who formerly was assistant superintendent of the department, succeeds the late **N. A. Hansen. Robert K. Mark** succeeds Mr. Wilkins as assistant superintendent. He formerly was general foreman at the Rod and Wire Department. Mr. Wilkins has been an employee at the Aliquippa Works since 1927, and has worked in the Rod and Wire Department for 30 years. Mr. Mark started as a metallurgical inspector at the Aliquippa Works in 1936. He became general foreman of the Rod and Wire Department in 1949. **William G. Wiley** succeeds Mr. Mark as general foreman of the Rod and Wire Department. Mr. Wiley was chief metallurgical inspector of the department and has been a J&L employee at the Aliquippa Works since 1940 when he started as a metallurgical inspector.

Russell M. Nein has been appointed superintendent of the cold strip mill at Armco Steel Corp.'s Middletown Works. He succeeds **Perry A. Hoss,** who is retiring after 46 years of service with Armco. Mr. Nein joined Armco in 1933, and worked for several years in the Hot Strip Mill Department. He moved to the cold strip mill as a crane leader in 1936, and held various positions there before being promoted to roll foreman in 1950. He became general foreman of the cold strip mill in 1952.

Harold E. Freeland has been named superintendent of the blooming and billet mills of Republic Steel Corp.'s Warren, Ohio, plant. He succeeds **J. P. Van Fossan** who has retired. Mr. Freeland joined Republic in 1932 and has held various positions in the open hearth shop and the hot strip rolling mill. He was promoted to assistant superintendent of the plant's hot strip mills in 1954 and assistant to the superintendent of the blooming and billet mills last year, the position he held until taking over his new duties.

Donald C. Osborne has been named assistant general superintendent of maintenance and services, Middletown Works, Armco Steel Corp. He succeeds **Robert S. Hayes,** who is retiring. At the same time, **Fred E. Gerber** was named to succeed **Carl W. Martin,** who is retiring, as superintendent of cold reduction finishing; **Forrest M. Morrow** has been appointed assistant general superintendent of rolling and processing; **Eli Komnenovich** becomes superintendent of coating, stainless, and finishing; and **Delbert S. Mann** has been promoted to superintendent of the East Processing Department.

Mr. Osborne joined Armco at the Middletown Works in 1933. He was appointed assistant to the superintendent of cold strip processing in 1941, and superintendent in 1946. He became superintendent of the East Processing Department in 1950. He was appointed assistant general superintendent of rolling and processing in 1957. Mr. Gerber joined Middletown Works in 1933. After several assignments in the Industrial Engineering Department he became works industrial engineer in 1944. In 1950 he was assigned to Armco's Hamilton, Ohio, plant as assistant supervisor of personal relations. He was advanced to superintendent of the East Processing Department at the Middletown Works in 1952. Mr. Morrow started with Armco in 1928 at the company's Ashland, Ky., Works. In 1931 he was placed on special assignment at the Hamilton plant. He moved to Middletown in 1932, and became general foreman of the Coating Department in 1934. He was promoted to assistant superintendent in 1945, and superintendent the following year. In 1952 he became superintendent of coating, stainless, and finishing. Mr. Komnenovich came to Middletown in 1936. After several positions in the Metallurgical Department he was promoted to senior metallurgist in 1946. He became assistant works metallurgist in 1949. Mr.

J. L. HOUGH

F. S. WILKINS

R. M. NEIN

H. E. FREELAND

H. K. SIEFERS, JR.

R. R. WAGSTAFF

H. S. MERCIER

R. L. McGRATH

Mann joined Armco at Middletown in 1935. He held several positions in the Processing Department at the plant and in 1945 was advanced to turn foreman. In 1952 he was promoted to general foreman in charge of temper rolling and finishing in the East Processing Department.

H. K. Siefers, Jr., has been appointed manager of the Engineering Service Department of the A. M. Byers Co. Mr. Siefers joined Byers in 1956, serving in the Engineering Department. He was previously associated with Hall Laboratory, division of Hagan Chemicals and Controls, as an engineer.

Robert R. Wagstaff has been elected engineering vice president and a director of United Engineers & Constructors Inc. He has been with United Engineers since 1937 when he joined the firm as an electrical field engineer. Since then he has held the posts of assistant electrical engineer, electrical engineer, supervising engineer and, most recently, chief engineer, to which he was named in 1956. Prior to 1937 he had been with American Smelting and Refining Co. for two years.

Harold S. Mercier, formerly general sales manager, was named vice president in charge of sales, The Tool Steel Gear and Pinion Co. Mr. Mercier has been associated with Tool Steel for the past seven years, occupying the position of general sales manager for the last five years. Succeeding Mr. Mercier in that position will be **R. L. McGrath,** formerly assistant general sales manager.

Robert R. Hayward has been appointed assistant works metallurgist at the Cleveland, Ohio, Works of Jones & Laughlin Steel Corp. Mr. Hayward, who formerly was strip mill metallurgist at J&L's Pittsburgh, Pa., Works, started in 1940 as a metallurgical statistical clerk at the Pittsburgh, Pa., Works. He since has held positions as metallographer, blooming mill inspector, open hearth and bessemer inspector, cold strip metallurgical turn foreman, and metallurgist in the Pittsburgh Works cold mill, strip mill, and bar mill.

Charles K. Pickering has been named assistant superintendent of the Electrical Department at Republic Steel Corp.'s Canton, Ohio, steel plant. He succeeds **Campbell Yothers,** who retired December 31. Mr. Pickering joined Republic in 1940, as a helper in a line gang at the Canton plant. He later was employed as a wireman until 1947, when he was selected to participate in the company's technical operating training program. Upon completion of this program in 1949, he was appointed substation foreman. Since 1951, he has been general foreman in the plant's Electrical Department.

Edward J. Sohn has been appointed vice president and general manager of Yuba-Bedford Corp., a subsidiary of Yuba Consolidated Industries, Inc. Mr. Sohn was chief engineer of the Bedford Foundry and Machine Co. from 1952 until its acquisition by Yuba last year.

Lloyd S. Campbell was appointed vice president of Michigan Limestone, a Division of U. S. Steel Corp. Mr. Campbell has been assistant to the vice president of operations of Oliver Iron Mining, another Division of U. S. Steel, at Duluth, Minn. Mr. Campbell joined the Oliver Iron Mining Division in 1936, working progressively as a mining engineer, assistant superintendent, and mine superintendent. He was promoted to assistant general superintendent of the Eastern district in 1952, and became assistant to the vice president of operations in 1956.

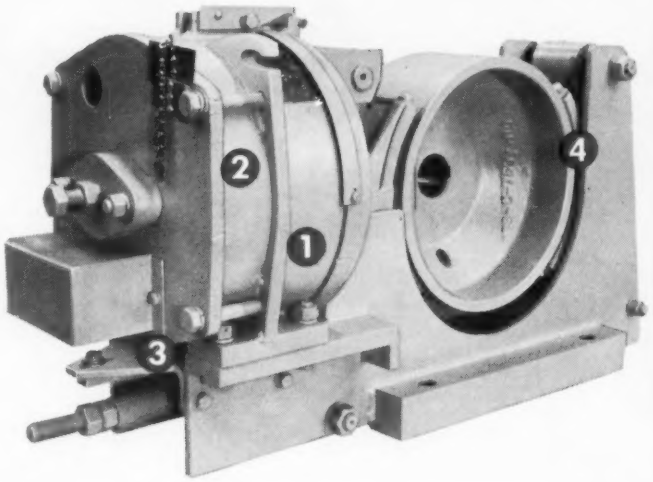
James M. Lange was named to the position of sales development engineer, The Chas. Taylor Sons Co. Mr. Lange was previously refractory engineer for the Bethlehem Steel Co. at Bethlehem, Pa.

Paul D. Terrien has been named sales representative for the mid-west area, Electrode Division, Great Lakes Carbon Corp. He formerly served in the Pittsburgh sales office. **Donald J. Palmisano** has been named sales engineer, specialties, at Kansas City, Mo. He formerly served as sales representative at the same location.

Joseph Surmacz has been named manager of the headquarters plant of Harnischfeger Corp., West Milwaukee, Wis. Mr. Surmacz joined the firm in 1951 as chief industrial engineer. **David Drewery** was appointed director of production and industrial engineering. He also joined the firm in 1951 and has, for the past five years, headed the Industrial Engineering Department. He will continue to administer that department and, in addition, will take on the supervision of production control, inventory control, and allied staff functions.

Albert J. Jones, has been made assistant superintendent of the plate and hot strip mills at the Gads-

MILL-DUTY ACCESSORIES



DC BRAKES

Single-end adjustment speeds maintenance and installation

New General Electric d-c brakes—featuring single-end shoe adjustment—are designed for easy maintenance and versatile installation. And, compensation for lining wear requires simple adjustment from only one end of the brake!

Here are more new features which make General Electric d-c magnet brakes your best buy for dependable, low-maintenance service:

1. **New magnet housing design** permits vertical removal, easy interchange.
2. **New coil** features all high temp. insulating materials potted in epoxy making brake ideal for the most rugged jobs.
3. **New pivot arm** assures equal shoe braking pressure.
4. **Easy lining replacement** does not require removal of brake shoe assembly . . . just lining.

Want details? See your G-E Apparatus Sales Engineer. Or, write Sect. 784-27, General Electric Co., Schenectady, N. Y., for Bulletin GEA-7067. *Industry Control Dept., Salem, Virginia.*

PUNCHED GRID RESISTORS

Designed for fast, low-cost installation

A combination of unique features makes corrosion-resistant, non-breakable, and all-welded General Electric punched-steel grid resistors easier, faster, and less costly to install. Key features are:

1. **Unique grid paralleling** saves time and expense since all parallel connections are made at factory. Grids come either series or parallel.
2. **Draw-out construction** speeds mounting in frame, assures positive alignment. Boxes are readily removed without disturbing those in place.
3. **Clip-lock and carriage-bolt fastener**—special device on runner guides locks box securely in frame. Front is bolted with only 2 self-holding bolts.
4. **All-purpose terminals** accommodate bus or cables. Taps provide means for adjusting resistance values.

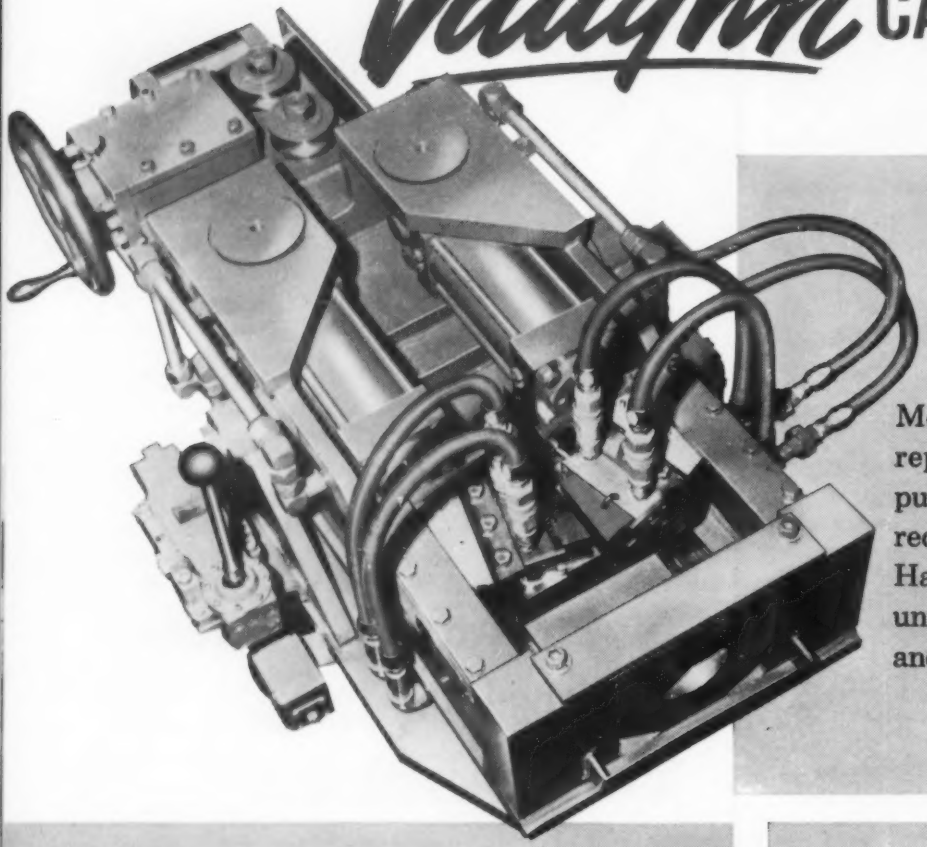
Like to know more? Contact your G-E Apparatus Sales Engineer, or write Sect. 784-27, General Electric Co., Schenectady, N. Y., for GEA-6858. *Industry Control Dept., Salem, Va.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

Name your **pointing** and **straightening** needs . . .

Vaughn® CAN MEET THEM!



New

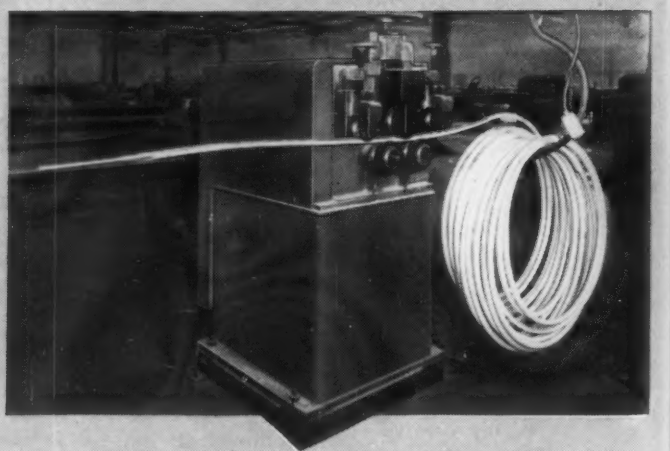
VAUGHN
HYDRAULIC PUSH POINTER

Mounted on the heavy duty Motobloc, replacing the die block, this compact push-type pointer eliminates floor space required for a separate 4-roll machine. Handling rod sizes from ½" to 1¼", the unit is hydraulically operated, and points and pushes rod through die into Motobloc.®

VAUGHN EXTRA HEAVY
4-ROLL CONTINUOUS POINTER

A specialized unit for heavy service, ruggedly constructed for long useful life. Accommodating rod from ½" to 1¼", this pointer has two vertical and two horizontal rolls—points rod easily without twist.

VAUGHN
ROLL STRAIGHTENER



Mechanically straightening the end of the coil in preparation for moving to pointer and die box, the 3-roll straightener saves time, manpower and money while boosting production. Unit with over-riding clutches is available for use with continuous processing lines.

"Quick on the Draw!"

The VAUGHN MACHINERY COMPANY

Cuyahoga Falls, Ohio, U.S.A.

COMPLETE COLD DRAWING EQUIPMENT . . . Continuous or Single Hole . . . for the Largest Bars and Tubes . . . for the Smallest Wire . . . Ferrous, Non-Ferrous Materials or their Alloys.

Vaughn Builds

A COMPLETE LINE OF POINTING MACHINES FOR ALL ROD AND WIRE SIZES

Write FOR DETAILS

den, Ala., plant of Republic Steel Corp. Mr. Jones, who was promoted from general foreman, joined Republic at Gadsden in 1956, while the hot strip mill was being constructed. Previously, he had spent seven years in South America, working for the Brasilian National Steel Co., and four years in Wales with the John Summers and Sons Co.

O. P. Ashurst has joined Auburn & Associates, Inc., as vice president in charge of the company's Detroit Mich., office. He will be responsible for company operations in the Detroit area and Canada. Mr. Ashurst was formerly chief engineer of Giffels & Valet, engineers and architects, and has been in independent consulting practice since 1957. He has been secretary of the Detroit district section of the Association of Iron & Steel Engineers for the past 15 years.

James S. Locke, newly elected corporate vice president, Minneapolis-Honeywell Regulator Co., becomes vice president and general manager of Brown Instruments Division. Mr. Locke, who had been vice president and general manager of Honeywell's Micro Switch Division since 1958, also will be responsible for operation of the Valve Division in Fort Washington, Pa., and the Fall River, Mass., Division. He succeeds **C. L. Peterson,** who becomes vice president of the company's central region, directing sales in Ohio, Michigan, western New York, and western Pennsylvania.

Curry E. Ford has been named director of marketing for National Carbon Co., Division of Union Carbide Corp. In his new position, Mr. Ford will have over-all marketing responsibilities for the company's complete line of industrial carbon and graphite products. He joined National Carbon Co. in 1937 after working for an engineering consulting firm, and in 1953 was named manager of chemical products sales. In 1957 he was made new products marketing manager, from which position he comes to his new assignment. These additional new assignments in National Carbon's marketing organization were announced: Reporting to Mr. Ford will be **James King, Jr.,** as manager of electrode products; **A. W. Wolff** as manager of industrial carbon products; **W. C. McCosh** as manager of carbon products; and **W. G. Pitt** as manager of new product market development.

Harry L. Buck, formerly vice president and general manager, has been elected to the newly-created post of executive vice president of I-T-E Circuit Breaker Co. At the same time, **A. E. Mackenzie,** previously vice president and general manager of I-T-E's Kelman Power Circuit Breaker Division, Los Angeles, Calif., was elected to the newly-established position of vice president—power equipment.

George A. Nemec has been appointed assistant superintendent of the blooming mills and the billet mill at the Cleveland, Ohio, steel plant of Republic Steel Corp. A veteran of 42 years service with Republic and a predecessor company, he was appointed a turn foreman on the mills in 1943. He became general foreman in 1950 and held this position at the time of his current appointment.

E. J. Mytkowicz has been appointed to the newly-created position of vice president in charge of operations of the Hewitt Rubber Division of Hewitt-Robins, Inc. Mr. Mytkowicz started with the company in 1947 as a project engineer in the Robins Conveyors Division plant, Passaic, N. J. He rose to the position of manufacturing manager of the plant, and then in 1956 was appointed manager of operations of the Jones Machinery Division, Chicago, Ill. Mr. Mytkowicz's successor in Chicago will be **R. A. Buese,** who was formerly manager of product sales of the Jones Machinery Division. Mr. Buese joined the Jones organization as a salesman in 1953. He was appointed manager of product sales in 1956.

Kenneth H. Mac Watt has been named manager of sales, Fabricated Products Division, the M. W. Kellogg Co., subsidiary of Pullman, Inc. He was previously the manager of piping sales, and joined M. W. Kellogg in 1952.

Donald Smith was named to the position of plant engineer of Michigan Seamless Tube Co. He has been associated with the company since 1953.

James P. Nagle, formerly sales engineer at Nagle Pumps, Inc., has been appointed sales manager of the company.

Robert E. Zimmermann has been appointed sales engineer with the Freyn Department, Engineering and Construction Division of Koppers Co., Inc. He is now in Italy on special assignment in connection with Koppers contract with Alti Forni E Acciaieri D'Italia, an Italian steel firm. Before joining Koppers, Mr. Zimmermann was associated with Eastern Gas &

J. S. LOCKE

C. E. FORD

H. L. BUCK

A. E. MACKENZIE

C. D. GABOR (left)
KARL KELLY (center)
GAVIN EMBRY (right)

Fuel Associates for 23 years. His most recent assignment was Blast Furnace Division superintendent at Everett, Mass.

Charles D. Gabor has been appointed chief engineer of Harbison-Walker Refractories Co. Mr. Gabor has been associated with Harbison-Walker since 1941. He has served as a draftsman in the Engineering Department, in general engineering work, and as a project engineer. In 1957, he was appointed assistant chief engineer.

Karl Kelly has been named manager of the Pittsburgh district sales office of I-T-E Circuit Breaker Co. He succeeds **B. W. Blose,** on leave of absence. Mr. Kelly has been manager of I-T-E's Buffalo, N. Y., district office for the past two years. He will continue to handle Buffalo area operations temporarily in addition to those of the Pittsburgh territory.

Gavin Embry was appointed industrial engineering manager of the Pacific Coast Engineering Co. Mr. Embry joined Paceco in 1957. He was formerly with Kaiser Engineers for 6 years where he was manager of organization and procedures.

Howard Dale Langley has been appointed marketing manager—motor control, Federal Pacific Electric Co. Formerly chief engineer of Square D Ltd. of England, Mr. Langley has also been associated with Master Electric Co., and the Square D Co. in various marketing, production and design engineering capacities in the industrial control field.

M. M. York has been named to the position of manager of marketing of the Industrial Equipment Division, Allis-Chalmers Manufacturing Co.

Mr. York joined Allis-Chalmers in 1939 as a graduate

EXECUTIVE REPORT #4

HEALTHY MOTORS BREATHE ULTRA-PURE AIR

...cleaned by **WHEELABRATOR**® air filters

Your investment in steel making equipment is too big to take a chance on motor failure resulting from dust in the atmosphere. Especially when Wheelabrator Ultra-Filtration air filters can provide essential air purity at minimum cost.

In prominent American and Canadian steel plants, Ultra-Filtration today is providing over 5,000,000 cfm of super-clean air for motor rooms, control rooms, electrical equipment and turbo blowers.

The low cost of operating Wheelabrator Ultra-Filtration air filters is gratifying, too. No liquids, oils or tacky materials are involved — there is no problem of sludge removal. In one typical installation, *absolutely* no maintenance cost has been experienced in filtering over 394,000 000,000 cf of air.

Ultra-Filtration provides any degree of air purity you require, at minimum cost

Ultra-Filtration delivers collection efficiencies above 99% by weight and 95% by blackness test, even when filtering sub-micron size particles. For illustrations of highly efficient Dustube installations, write for Catalog 562-D. **Wheelabrator Corp., 396 S. Byrkit St., Mishawaka, Ind. In Canada, P. O. Box 490, Scarborough, Ont.**

WHEELABRATOR
DUST AND FUME CONTROL

engineer trainee. In 1941 he was assigned to the Charlotte, N. C., district office as a sales representative. He was appointed manager of the Boston, Mass., district office in 1950 and a year later manager of the New England region. He became manager of the North Central region in 1954 with headquarters in Chicago, Ill., the post held at the time of his present appointment.

Nye S. Spencer, formerly sales manager of the switchboard section of Switchgear Division, has been appointed manager, utility marketing, of I-T-E Circuit Breaker Co. he replaces **Robert D. Cleaves,** resigned. At the same time, **William A. Donaldson, Jr.,** previously manager of contractor sales, switchboard section, has been named to succeed Mr. Spencer. Mr. Spencer has been with I-T-E for 13 years. Prior to being named sales manager of the switchboard section in 1956, he was an equipment sales manager in that section. Before that he was a field application engineer in the Chicago sales office. Before joining I-T-E, Mr. Donaldson was an application engineer with Westinghouse Electric Corp., and an electrical engineer with Sargent & Lundy Co.

Obituaries

Lewis L. Hill, sales engineer for the Hyatt Bearings Division of General Motors Corp., died February 11. He was 63. Mr. Hill had been handling steel mill, machine and motor building accounts from Hyatt's Pittsburgh, Pa., sales office since 1925.

J. S. MURRAY

John S. Murray, Pittsburgh District sales manager for Alliance Machine Co., died March 16. Mr. Murray was formerly employed by Westinghouse Electric Corp. and by Follansbee Steel Corp. where he served as chief electrical engineer for 26 years prior to joining Alliance in 1945.

Mr. Murray was prominent in AISE activities for many years and held various national offices. He had served as secretary of the Pittsburgh district for the past 15 years

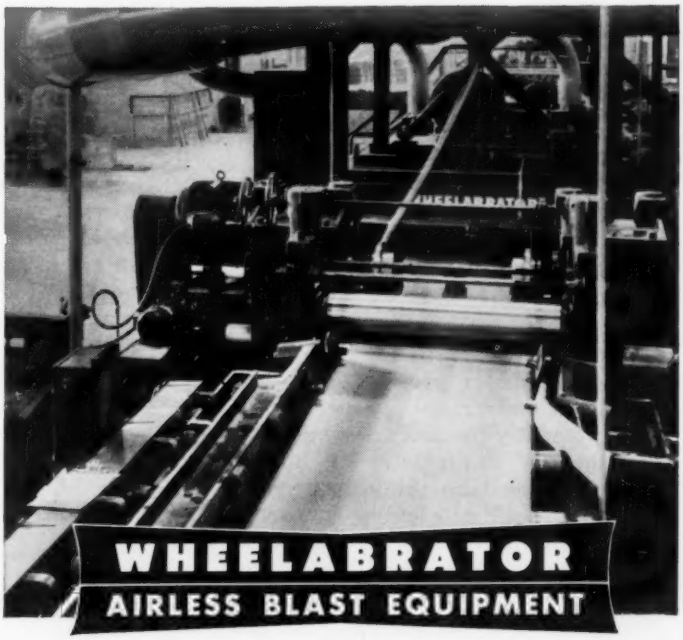
EXECUTIVE REPORT #12

A PIPE DREAM COMES TRUE

Wheelabrator® cleans skelp edges at new low cost

Another example of steel industry savings made possible by Wheelabrator mechanical descaling is the exceptional economy realized by pipe rolling mills in cleaning of skelp. Here it is desired to clean only a small strip along both edges of the bottom side of the skelp, which will be butted together and electro-welded.

In the Wheelabrator process, two blasting wheels are positioned to pinpoint their abrasive barrage along the edges, giving fast, thorough cleaning of these surfaces only.



Wheelabrator leads in mechanizing steel mill descaling methods

In over 100 installations in all types of steel mill applications, Wheelabrator has proven its cost-saving benefits. For engineering consultation call or write Wheelabrator Corporation, 396 S. Byrkit St., Mishawaka, Indiana. In Canada, P. O. Box 490, Scarborough, Ontario.

From the pulpit, all operations of the new furnace are controlled by this operator with the help of Speedomax H instruments.

Modern Automatic Controls by L&N Help Sheffield Meet Demand

Speedomax® H regulates temperatures of new Drever heat-treat line

THE boom is on down Texas way and the Sheffield Division of Armco Steel Corporation is keeping up with the demand for quality steel products by modernizing and expanding their Houston facilities.

A new remotely-controlled Drever roller hearth heat-treat line is among the major projects recently completed and placed in operation. Used presently for processing round bars up to 8″ in diameter and up to 30′ long, the line includes three furnaces: a 45′ hardening furnace, a 45′ holding furnace and a 124′ tempering furnace.

Because temperature control in all the furnaces is critical, a total of 16 Speedomax instruments were chosen to provide detailed readout of temperature conditions and automatic adjustment of the gas valves. Six of these are easy-to-read Speedomax H indicating-controllers which regulate temperature in the 3-zone hardening and holding furnaces. Records of temperatures in these furnaces are printed out on two 3-point Speedomax G recorders. For the 8-zone tempering furnace, Speedomax H strip-chart controllers provide close control and reliable charting of temperature conditions in each zone.

Efficient installations such as this are the result of control engineering and design teamwork . . . teamwork that furnace manufacturers and users alike can depend on when specifications read, "control by Leeds and Northrup."

Take a tip from major companies like Sheffield and Drever. Call your nearby L&N engineer at one of 34 convenient offices. Or write 4942 Stenton Avenue, Philadelphia 44. We'll see that you get full information about the solution to your control requirements.

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

YOU GET BIGGER SHAFTS IN THE SAME SPACE WHEN YOUR "SPECS" READ HYATT

To gain more space, simply eliminate the separable race from a Hyatt Hy-Roll bearing. For Hyatt rollers will operate directly on any shaft or bore that you've hardened and ground to bearing specifications. But, first be sure you're using Hy-Roll bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT *HY-ROLL BEARINGS*

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM GENERAL MOTORS RELIABILITY

3 All New electric

. . . to make

FEATURES:

- Wide band adjustments: 0 to 500% prop. band, 0 to 100 repeats/min. reset, and 0 to 10 min. rate.
- Bumpless transfer even when control output is changing.
- Change proportional band any amount without upsetting process.
- Rate action circuit minimizes overshoot in batch process and during startup.
- Pull-out chassis for servicing without interrupting operation.
- Modular construction simplifies maintenance and stocking.
- Plug-in silicon diode rectifiers for greater reliability.

All three units use the same plug-in components . . . only the control output section is different. Simplifies on-the-job servicing . . . eliminates need for complicated test equipment.

3-mode control units

furnaces perform at their best

***Electr-O-Line* Control Unit**—For electronic position-proportioning control with reset and rate action

***Electr-O-Pulse* Control Unit**—For electronic time-proportioning control with reset and rate action

***Electr-O-Volt* Control Unit**—For electronic current output proportioning control with reset and rate action

One of these units—*Electr-O-Line, Electr-O-Pulse* or *Electr-O-Volt*—will deliver the exact kind of temperature control that's best for your furnace.

Plug-in construction is used throughout all three units—including common amplifier and power supply sections. Operator adjustments are exactly alike for all three units. Interchangeability of control output sections simplifies stocking and service problems.

Get complete details on these and other types of furnace controls from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

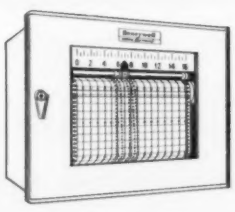
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

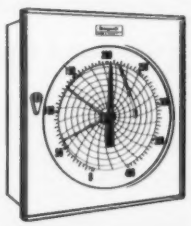
Honeywell

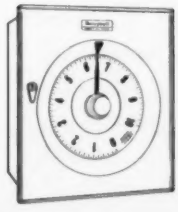
First in Control

SINCE 1885

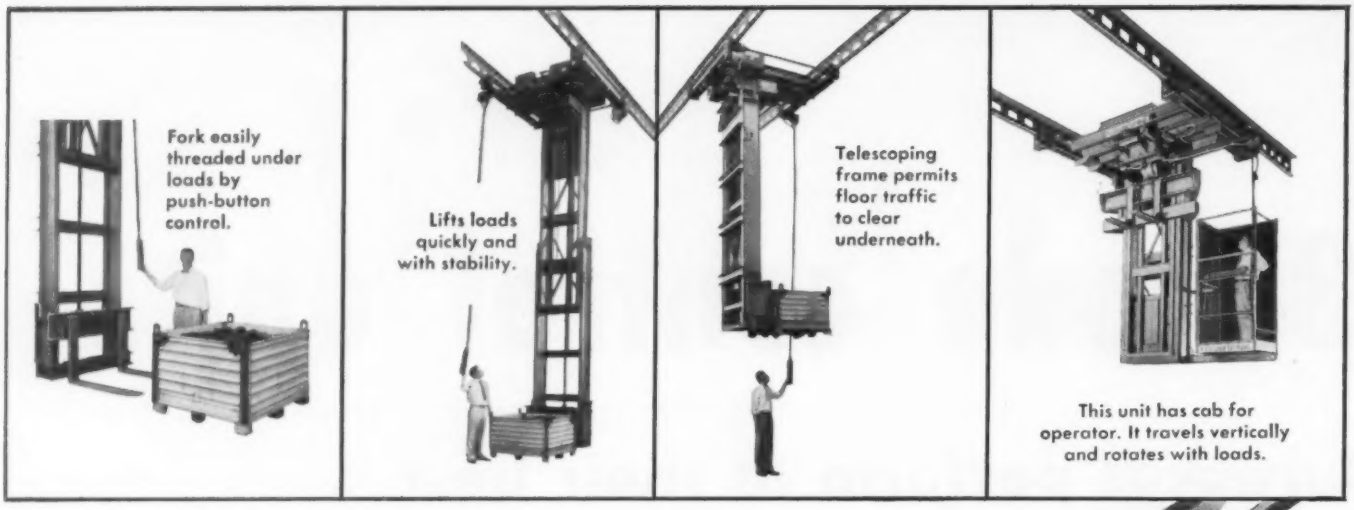
75th YEAR — PIONEERING THE FUTURE



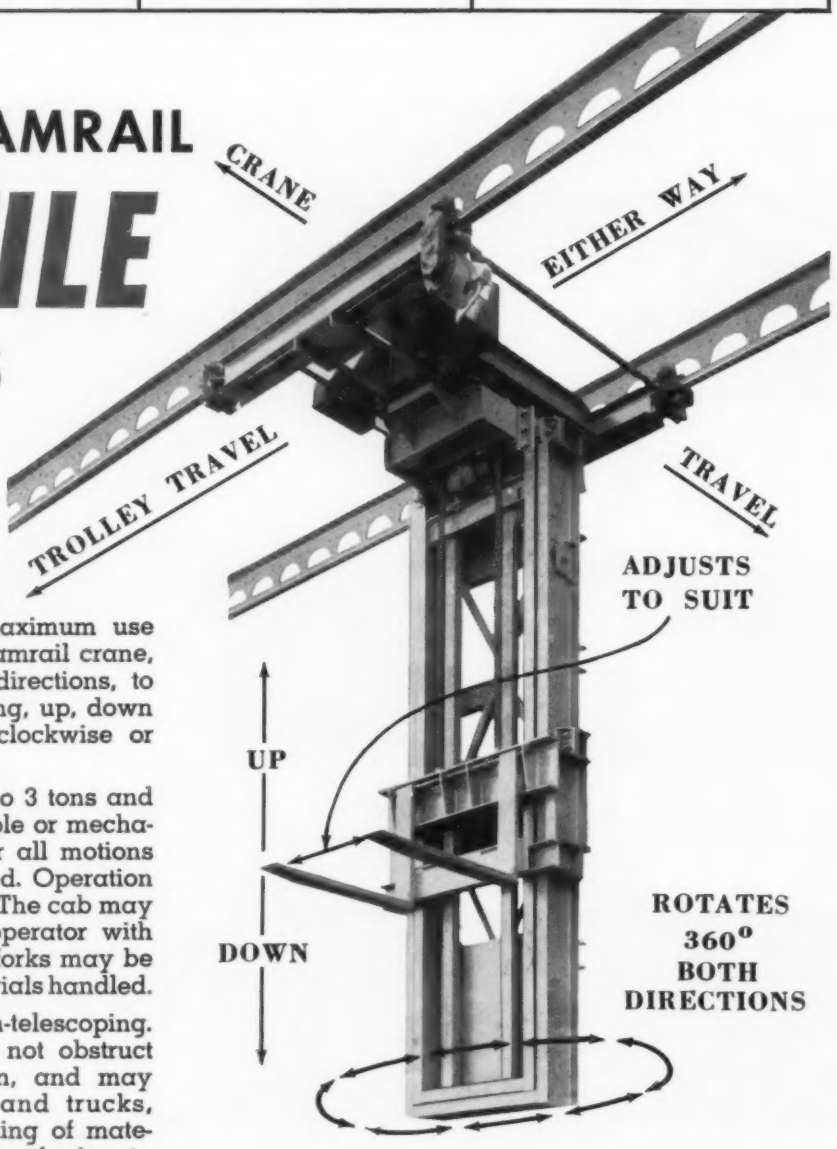




Use *ElectroniK* strip chart, circular chart or circular scale controllers to actuate *Electr-O-Line, Electr-O-Pulse* or *Electr-O-Volt* units. They are integrally mounted, simplifying panel cutout and reducing wiring costs.


Fork easily threaded under loads by push-button control.
Lifts loads quickly and with stability.
Telescoping frame permits floor traffic to clear underneath.
This unit has cab for operator. It travels vertically and rotates with loads.

CLEVELAND TRAMRAIL
VERSATILE
STACKERS



THE maneuverability of Cleveland Tramrail stackers enables obtaining highly efficient handling coverage of a warehouse with maximum use of space. When on a Cleveland Tramrail crane, a stacker can be traveled in all directions, to front, rear or either side of a building, up, down and turned through a full circle clockwise or counter-clockwise.

Stackers are available for loads to 3 tons and lifts to 20 feet. They may be as simple or mechanized as the work requires. Any or all motions may be manually or power operated. Operation may be controlled from floor or cab. The cab may be traveled vertically to provide operator with maximum visibility of work. Lifting forks may be designed and spaced to suit the materials handled.

Design may be telescoping or non-telescoping. Telescoping type (illustrated) does not obstruct aisleways when in raised position, and may be traveled over railroad cars and trucks, thereby permitting the direct handling of materials to storage without need of transferring to other conveyances.

Cleveland Tramrail stackers and supporting cranes have much to offer. They can be designed to exactly suit your needs. Why not have a nearby Cleveland Tramrail engineer fill you in on the details.

CLEVELAND TRAMRAIL

Overhead Materials Handling Equipment

CLEVELAND TRAMRAIL DIVISION • THE CLEVELAND CRANE & ENGINEERING CO. • 5054 E. 290 ST. • WICKLIFFE, OHIO

Publication Service...

APRIL 1960

(1) Ground Gears

Philadelphia Gear Corp. has issued a booklet describing the advantages in using hardened and precision ground gears. New methods, facilities and applications are fully illustrated and described in detail. Highly accurate gear cutting and grinding facilities with scientific profile and flank control are described along with their methods of maintaining extremely high standards of quality control throughout production. Various applications for precision ground gears in radar drive units, rotary wing aircraft, high-speed gas turbine drives, dredge cutter drives, marine propulsion and others are illustrated.

(2) Vacuum Melted High Temperature Alloy

A new booklet entitled, "W-545 Vacuum Melted High Temperature Alloy," is available from the Westinghouse Electric Corp. This technical data booklet is complete with photomicrographs showing structures of the material and many tables and graphs illustrating the material's properties. In addition to general information on applications, other sections of the booklet deal with metallurgical characteristics, physical properties, mechanical properties, creep and creep-rupture properties, availability and material processing of W-545 alloy. (Data Sheet 152-263)

You Can Obtain . . .

. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(3) Graphite Heat Exchangers

The Carbone Corp. offers a new 20-page engineering manual presenting their impervious graphite heat exchangers. This manual features full-page illustrations, cutaways, diagrams and design data. Also included are charts, graphs, typical calculations, examples and specifications. The principles of operation are clear and well demonstrated. At the back of the manual there is a full-page, perforated inquiry-data sheet which should prove valuable to companies seeking further information and a solution to current problems.

(4) Soaking Pit Control Systems

Recently issued by Hagan Chemicals & Controls, Inc., is a brochure describing their soaking pit control systems. The illustrated publication ranges in subject matter from a description of the soaking pit operation to schematic drawings of several successful control system installations. The transition from hydraulic to pneumatic to electronic controls is outlined, together with a summary of Hagan research work in this area. Four types of control systems with varying requirements are described in detail, with special emphasis on centralized soaking pit control by means of solid-state, magnetic components. Recuperator protection and temperature overshoot are discussed, together with diagrams and charts showing method for overcoming these problems. (Bulletin MSA-177)

(5) Miniature Vertical Gages

Miniature vertical-type gages with 5-in. scales for measuring and indicating draft, pressure, differential pressure, temperature and pneumatic signals are described in a new bulletin issued by Republic Flow Meters. The bulletin shows such gage features as scales and ranges available, mounting dimensions and lighting details. (Bulletin 59-1)

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IRON & STEEL ENGINEER

1010 EMPIRE BUILDING

PITTSBURGH 22, PA.

IRON & STEEL ENGINEER

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PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	ALLIS CO., LOUIS, THE	BULLETIN 2001	Adjustable speed drive
51	ATLAS CAR & MFG. CO.	BULLETIN 1283	Transfer equipment
52	AUTOMATIC TRANSPORTATION CO.		Elbolift
53	BABCOCK & WILCOX CO., THE	BULLETIN R-35A	Refractory castables
54	BLISS CO., E. W.	CATALOG 40-B	Rolling mills
55	BLISS CO., E. W.	BULLETIN NO. 60	Pulsation burner
56	BROOKS OIL CO., THE		Lubricants
57	BUSSMANN MFG. DIV., McGRAW-EDISON CO.		Fuses
58	CLARK CONTROLLER CO., THE	BULLETIN 250-ND	Safety switches
59	CLEVELAND WORM & GEAR DIV., EATON MANUFACTURING CO.	BULLETIN NO. 145	Speed reducers
60	CONE-DRIVE GEARS, DIV., MICHIGAN TOOL CO.	BULLETIN CD-218	Speed reducers
61	DIAMOND ELECTRONICS, DIV. OF DIAMOND POWER SPECIALTY CORP.	FIELD SURVEY FS33A	Industrial television
62	DRAVO CORP.	BULLETIN NO. 247	Sintering discs
63	ELECTRIC MACHINERY MFG. CO.	E-M FOTO-FACTS NO. 16	Motor drives
64	ELWELL-PARKER ELECTRIC CO., THE		Electric fork trucks
65	EUCLID ELECTRIC & MFG. CO., THE	BULLETIN E-3004	Heavy-duty resistors
66	FALK CORP., THE	BULLETIN 4100	Couplings
67	FARRELL-CHEEK STEEL CO.	CATALOG 24	Alloy and carbon cast steel wheels
68	GARLOCK PACKING CO., THE	CATALOG 30	Oil and grease seals
69	GENERAL ELECTRIC CO., X-RAY DEPT.	PUB. IS-44	X-ray emission gage
70	GENERAL ELECTRIC CO.	BULLETIN GEA-7067	D-c magnet brakes
71	GENERAL ELECTRIC CO.	BULLETIN GEA-6858	Punched grid resistors
72	GPE CONTROLS, INC.	BULLETIN EG84	Controls
73	HAGAN CHEMICALS & CONTROLS, INC.	BULLETIN MSP-163	Analog computer control
74	HAUCK MANUFACTURING CO.		Gas burners
75	HEWITT-ROBINS	BULLETIN 4-50	Speed reducer lines
76	I-T-E CIRCUIT BREAKER CO.	BULLETIN 4601-A	D-c breaker
77	JOHNS-MANVILLE	IN-190A	Insulation
78	LARCO INC.	BULLETIN AC-573	Crane cab and pulpit air conditioners (aire rectifiers)
79	LINK-BELT CO.	CATALOG 2747	Gearmotors and motogears and fluid drives
80	LINK-BELT CO.	CATALOG 2751	Gear speed reducers
81	LINK-BELT CO.	CATALOG 2724	Worm gear speed reducers
82	LINK-BELT CO.	CATALOG 2719	Parallel shaft speed reducers
83	LINK-BELT CO.	BOOK 2764	Bulk handling equipment
84	MARATHON SPECIALTY STEELS, INC.	TECHNICAL BULLETIN SR-11	Forged steel rolls
85	MORGARDSHAMMAR		Roller guides
86	NORTH AMERICAN MFG. CO., THE	DF-6819	Refractory-lined dual-fuel burners
87	NORTHEAST OHIO MACHINE BUILDERS, INC.	BULLETIN NO. 360	Stenciling machines
88	PENNSYLVANIA CRUSHER DIV., BATH IRON WORKS CORP.	BULLETIN 9002	Granulators
89	PENNSYLVANIA CRUSHER DIV., BATH IRON WORKS CORP.	BULLETIN 3007	Bradford breakers
90	POST-GLOVER ELECTRIC CO., THE		Resistors
91	RAMTITE CO., THE		Alumina ramming mix
92	SELAS CORP. OF AMERICA		Gradiation heating in steel mills
93	SPRAYING SYSTEMS CO.	CATALOG 24	Spray nozzles
94	SQUARE D CO., EC&M DIV.	BULLETIN 6121	Front-connected d-c control
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96	STEPHENS-ADAMSON MFG. CO., STANDARD PRODUCTS DIV.	BULLETIN 260	Catenary carriers for belt conveyors
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99	TAYLOR CHAIN CO., INC., S. G.	BULLETIN 14-A	Alloy chain
100	TAYLOR INSTRUMENT COS.	BULLETIN 98335	Electronic flow transmitter
101	TAYLOR INSTRUMENT COS.	BULLETIN 98333	A-c or d-c electronic recorder
102	TORRINGTON CO., THE	CATALOG #258	Spherical roller bearings
103	UNION CARBIDE METALS CO.	FOLDER F-20,118	Ferroalloys and metals
104	WEIGHING & CONTROLS COMPONENTS, INC.	BULLETIN 40	Weigh-hopper systems
105	WHEELABRATOR CORP.	CATALOG 562-D	Ultra-filtration air filters
106	WHITING CORP.	CATALOG NO. FY-168	Hydro-arc electric furnaces
107	YODER CO., THE		Tube mill book

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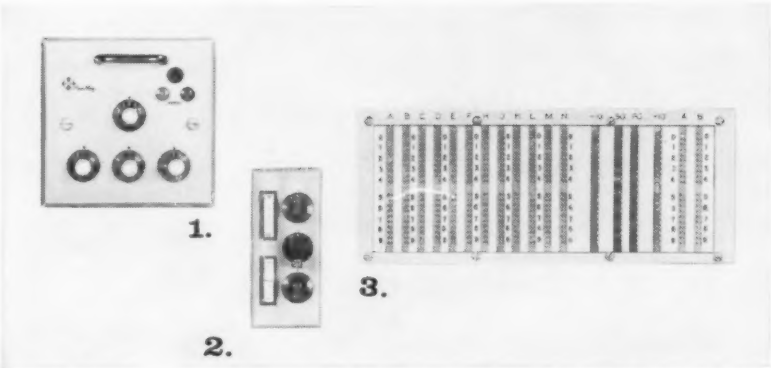
BLAW-KNOX

Blaw-Knox designs and builds a full range of mills for the reduction of aluminum and other non-ferrous metals. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals, sheet and strip processing equipment, electrolytic tinning, annealing, and galvanizing lines, seamless pipe and tube mills, draw benches, and cold draw equipment, Blaw-Knox Medart cold finishing equipment, iron, alloy iron and steel rolls, carbon and alloy steel castings, fabricated steel plate or cast-weld design weldments, steel plant equipment, and heat and corrosion resisting alloy castings. Blaw-Knox Company. Foundry and Mill Machinery Division, Blaw-Knox Building, 300 Sixth Ave., Pittsburgh 22, Pa.

32- and 56-inch x 96-inch, 4-high reversing hot strip mill at the Terre Haute plant of Anaconda Aluminum Company.

Hagan PowrMag Analog Computer Control

simple as



PowrMag systems embody the highest degree of flexibility. Simple, efficient electrical design utilizing long-lived and trouble-free solid state components, and rugged mechanical construction suit the system for a variety of industrial process control applications.

1. *Magnetic Control Unit*

This magnetic amplifier, operating on 1-9v DC, may be used individually, as a single 2 or 3 mode controller, or as one element in a large system. Each control unit may be removed from the front of the panel for easy interchangeability. The basic unit is easily converted to other modes by the addition of interchangeable, plug-in circuits for *all* common control operations. Inventory is reduced to the one basic unit. Unaffected by shock or vibration, PowrMag has no moisture, dirt, leakage or freezeup problems—3.5 watts of unregulated 110v, 60 cycle AC. Size—5¼″ x 5¼″.

2. *Remote Control Station*

These stations provide for remotely established set points and required manual control operations. Full station may contain two single or ganged potentiometers, one switch and two meters. Size—2¼″ x 5¼″. Half stations available with set point, bias or ratio dial and output signal indicator. Size—2¼″ x 3⅛″. Each station uses 12-wire, color-coded electric cable with MS-type connector. Front mounting and removal make it ideal for the compact console installations required for centralized control.

3. *Patchboard*

Interconnecting the system in any desired manner, via color-coded electrical cable, the patchboard requires no solder connections or terminal boards—all connections are made by special taper pins. Each connection is identified by an alphanumeric combination. Numbers, run vertically, identify the components in the system, such as magnetic amplifiers, controllers, transducers, etc. Letters, run horizontally, identify the connectors leading into the patchboard. DC control power bus is in the center section—no AC voltages are used in the patchboard.

Easy front access permits simple changing of operations. Additional loops or components are readily added to the system.

A letter or phone call will bring you complete information on the PowrMag system. **Ask for Bulletin MSP-163.**

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PENNSYLVANIA

HAGAN DIVISIONS: CALGON CO. — HALL LABORATORIES — BRUNER CORP.

Another RAMTITE® Contribution to Refractory Users . . .

Composite picture showing RAMTITE breastwall with 90-RAM veneer, unfired. 18 other holes in this large mill have the same application. (Note Ramtite No. 25 checker roof.) Also shown is Ramtite division wall construction with 90-RAM slag line veneered to Ramtite No. 25. This is one of several division walls of the same construction in a large Ohio mill.

90-RAM—*A 90% Alumina Ramming Mix—Air Setting*

HERE'S AN EXAMPLE OF ITS EFFECTIVENESS AND VERSATILITY: Starting in November, 1957, 90-RAM was installed in several trial sections in slag lines of soaking pit walls in an Ohio mill. These trials varied in veneered thicknesses from 3″ to 6″, and to date all have been successful.

Here, the Calorific was *Terrific!*

No. 20 pit in this blooming mill is a run-away (sometimes uncontrollable) and the 90-RAM patch in this particular pit has been subjected to the melting down of five tons of a 10-ton ingot, and the boiling action of slag and metal was readily visible. When this pit was inspected recently, the 90-RAM showed no deterioration of any sort — it turned color a little, and that's all.

90-RAM was developed by our Research Department for lining the laboratory furnaces used to check test each day's production of Ramtite No. 25. For 60 months of daily use, 90-RAM has furnished completely trouble-free service! It is no longer a new product as it is *now being used by many of the Largest steel plants in the country for a variety of applications.*

90-RAM already has been outstandingly successful in such diverse applications as hearths, roofs, sidewalls and burner ports in continuous reheat furnaces; forge heating furnace hearths and slag lines; in ferrous and nonferrous fuel and electric melting furnaces; in soaking pit slag lines, and in several places in basic open hearth furnaces.

Send for new folder which tells complete story about 90-RAM. Use the handy coupon.

The Ramtite Co.
DIV. OF THE S. OBERMAYER CO.
1813 South Rockwell St., Chicago 8, Ill.

THE RAMTITE CO., Div. of the S. Obermayer Co.
1813 South Rockwell St., Chicago 8, Ill.

Please send the items checked:

☐ 90-RAM Folder
☐ We are interested in Ramtite. Please send information.

Company Name_____

Attn. Mr._____ Title_____

Address_____

City_____ Zone____ State_____

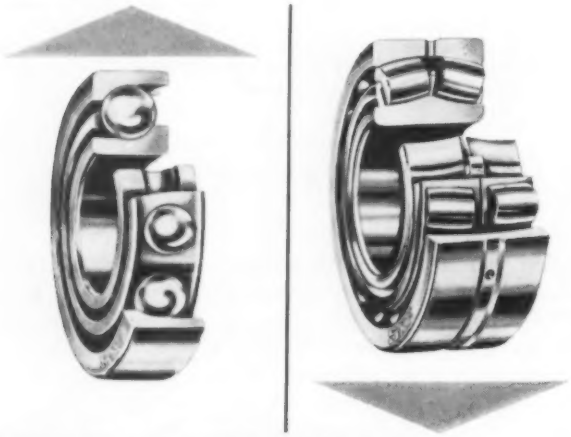
EVERY TYPE—EVERY USE
SKF®
INDUSTRIES, INC., PHILADELPHIA 32, PA.

Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings

ANGULAR CONTACT BALL BEARING

This is the bearing to use when you need a high-speed bearing to support either (a) heavy thrust load, or (b) thrust load combined with radial load. It lends itself to various mounting arrangements. For example, if you need axial rigidity and high radial capacity you can mount two of these bearings in pairs either face-to-face or back-to-back. Or, if very high thrust capacity is needed, you can mount two or more of these bearings in tandem.

This standard bearing is available in over 80 sizes of single- and double-row types. Bore sizes range from ¾" to just over 7".



SPHERICAL ROLLER BEARING

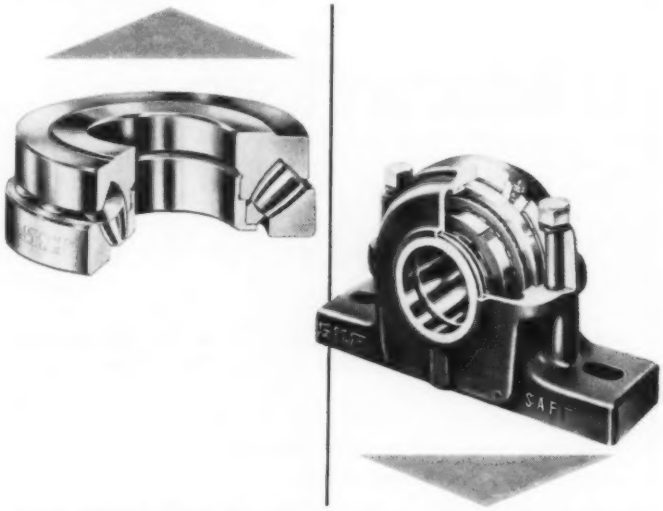
SKF invented the spherical roller bearing almost forty years ago. Since then, we've improved the original design several times—so that, today, our Type "C" spherical roller bearing offers longer life and 33⅓% greater capacity.

This increased capacity is largely due to the number, size and shape of the rollers—and the improved accuracy with which they're guided. Because these bearings are inherently self-aligning, their full capacity is always available for substantial thrust load in either direction as well as heavy radial load. These bearings also have special lubricating grooves that channel lubricants directly to the spherical rollers.

SPHERICAL ROLLER THRUST BEARING

Need a thrust bearing capable of carrying unusually heavy loads? Then specify this self-aligning spherical roller thrust bearing. It will carry either heavy thrust or combined thrust and radial loads. Because of its ability to carry high thrust at high speeds, this bearing is frequently chosen over large angular contact ball bearings for heavy-duty applications.

SKF makes this bearing in twenty-five standard sizes ranging from 4.3" to 14.9". And it's competitively priced.



TYPE SAF PILLOW BLOCK...with self-aligning ball or spherical roller bearings

Here's a rugged cast-iron pillow block that provides high efficiency with low friction.

We make this split pillow block with ball bearings for normal loads and with spherical roller bearings for heavy loads. We also equip it with Triple-Seal rotating rings that effectively protect the bearing from abrasives and corrosives, and prevent oil or grease from leaking out.

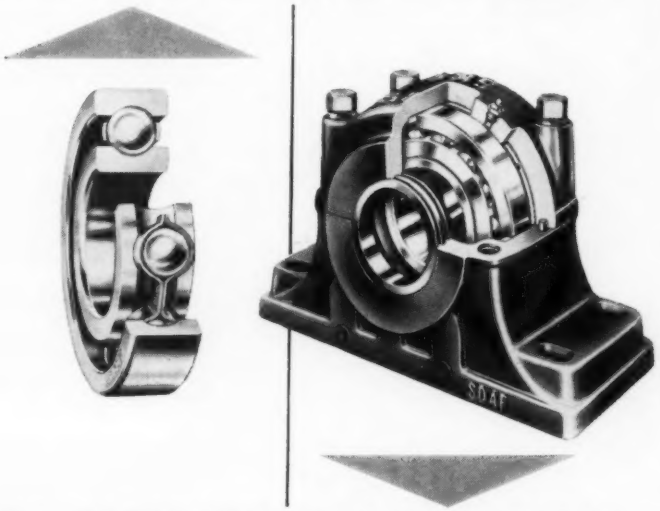
This pillow block can be mounted directly or with an adapter. Stabilizing rings are provided at no extra cost for applications where a "held" bearing is required to maintain shaft location. For heavy-duty applications, a cast steel housing (Type SAFS) is available. Shaft sizes from ¾" to 10½".

Only SKF can offer you unbiased bearing recommendations—because only SKF produces all four major types of anti-friction bearings: spherical, cylindrical, ball, and tapered roller bearings. For complete details on each type, just call the nearest of the twenty-four SKF sales offices.

SINGLE-ROW DEEP-GROOVE BALL BEARING

Here's a ball bearing that does two jobs, and does both of them well. It sustains heavy radial load as well as thrust load in either direction. Not only that, this bearing can be grease-lubricated when used at normal speeds and lubricated with oil at high speeds.

Yet this is a standard SKF bearing, mass-produced in various sizes at our automated Altoona (Pa.) plant. It's available in over 100 sizes ranging from over 5/8" O.D. to almost 16" O.D., and with various seal, shield and snap-ring combinations.



TYPE SDAF PILLOW BLOCK...with spherical roller bearings

Need an exceptionally sturdy pillow block? One that can withstand abnormal shock loads or heavy thrust loads day after day? Then specify SKF Type SDAF.

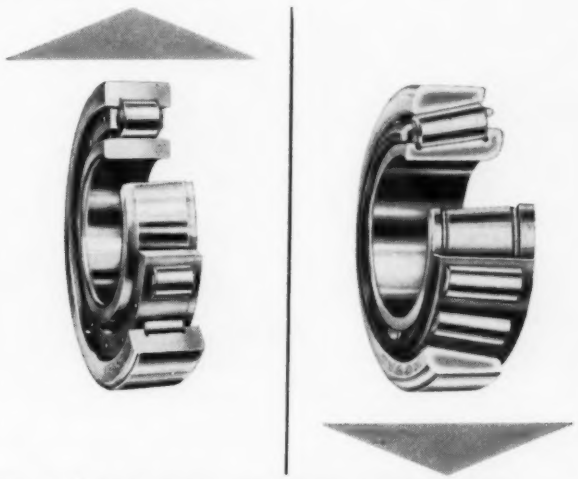
To provide maximum strength, four heavy bolts secure the cap of this pillow block to the base. Both halves are accurately aligned by dowel pins. And like the Type SAF, this pillow block comes equipped with Triple-Seal rotating rings that protect the bearing from foreign matter and retain the lubricant.

Type SDAF pillow blocks are made of cast iron but are also available in cast steel (specify Type SDAFS). They can also be mounted directly or with an adapter. Shaft sizes range from 2-11/16" to 14".

CYLINDRICAL ROLLER BEARING

Got a space problem? Here's a bearing that gives you high radial capacity—at very high speeds—in relatively small space. It's the SKF cylindrical roller bearing—which provides high radial capacity and minimum shaft friction. Controlled shaft end float within this bearing is a natural advantage of its design.

You can get prompt delivery in 154 bore sizes ranging from just under 1" to 6". Double-row cylindrical roller bearings are also available in bore sizes from 1" to 9.5".



Tyson* TAPERED ROLLER BEARINGS

What type of tapered roller bearing do you need: single-, double- or four-row? SKF's division, Tyson Bearing Company, makes all three of these types in a wide range of standard sizes.

The single-row type is especially suitable for carrying radial loads simultaneously. Double-row types are designed for use where the radial capacity of two single-row bearings is required. For special applications, the four-row type offers very high radial capacity in limited space.

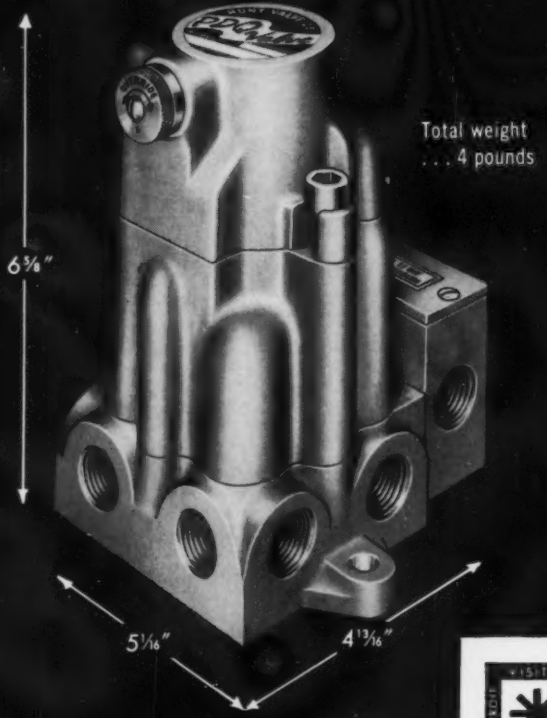
All Tyson tapered roller bearings are interchangeable, size for size, with other makes of tapered roller bearings where the part numbers are the same.

5949

* REG. U. S. PAT. OFF.

THE HUNT PDQ

has Faster Response Time and Greater Capacity than Air Valves—*4 Times Its Weight and Twice Its Size!*



Total weight
. . . 4 pounds

VISIT OUR BOOTH
'60
ASTE TOOL SHOW
BOOTH NO. 301

You asked for a light, compact valve

Here is a full 1/2" air valve at **4 pounds.** It will flow 335 c.f.m. with 100 p.s.i.g. initial pressure to atmosphere. It measures 6-1/2" high by 5-1/16" wide by 4-13/16" deep.

You asked for speed and capacity

Here is what the Hunt PDQ is capable of. Response time to fill a 140 cubic inch vessel to 90 p.s.i.g. with an initial pressure source of 100 p.s.i.g. is .113 seconds. (6.8 electrical cycles.) To exhaust the same vessel from 90 to 10 p.s.i.g. is .195 seconds. (11.7 electrical cycles.)

The short-stroke pilot actuates a compact, full-orifice poppet-spindle amazingly fast . . . renders traditional air valves obsolete.

The Hunt 1/2" PDQ air valve is designed to do the things you've wanted a valve to do since the advent of automation. Write us today.

N. C. HUNT, PRESIDENT

HUNT VALVE COMPANY · SALEM, OHIO, U. S. A.

- ☑ Accessibility
- ☑ Simplicity
- ☑ Speed and Capacity
- ☐ Price and Quality

The Hunt PDQ valve tops them all in every class.

Next month . . .
the PRICE and QUALITY story.

HUNT HVC ***Quick-As-Wink*** AIR & HYDRAULIC CONTROL VALVES

Another example of National Roll quality control

Elmer Grinder, left, of National's steel foundry discusses chill location with Bill Williamson of the Sales Department.

Roll molds determine life, not just dimensions

Molding techniques for steel rolls are, of course, directed at obtaining a casting with accurate dimensions for economical machining into precise shaped or plain rolls.

But just as important as dimensions —determined by the "sweep" pattern shown above—is the metallurgical function built into every roll mold. Metal "chills" are carefully located to control cooling of the steel in a manner that will produce a roll both metallurgically and physically sound.

Started on paper, the chill layout is translated into a mold of metal and sand under the watchful attention of National's experienced steel foundry personnel. These men know foundry practice. But perhaps more importantly, they know the demands that are made on roll soundness in the customer's mill.

This is a part of National's service which means better rolls for you. It's one of the many reasons why . . .

National's the growing name in rolls

NATIONAL ROLL & FOUNDRY DIVISION

GENERAL STEEL CASTINGS CORPORATION, Avonmore (Westmoreland County), Pa.

General Steel Castings Corporation, General Offices: Granite City, Illinois • Plants: Granite City, Ill., Eddystone, Pa., Avonmore, Pa.

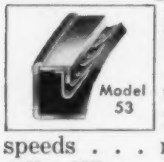
ENGINEERED OIL SEALS for Steel Mills

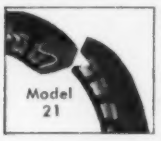
Garlock KLOZURE Oil Seals protect vital bearings from damage, add to efficiency of new Jones & Laughlin punch card-operated continuous mill at Aliquippa, Pa.

Jones & Laughlin Steel Corporation specifies Garlock KLOZURE* Oil Seals to protect important bearings on new punch card-operated mill at Aliquippa.

At dozens of vital locations on the 44" 4-Hi Continuous Mill—approach and runout tables, vertical edgers, coilers, rotary crop shears—the Garlock KLOZURE Oil Seals perform a double duty. They stop leakage of lubrication from the bearings, prevent harmful scale, spray, dirt from getting to the bearings.

In wide use today throughout the steel industry, Garlock KLOZURE Oil Seals are available in a wide range of designs. For example, Model 142, a face-type KLOZURE, is designed to seal surfaces perpendicular to shaft . . . keeps water splash and scale out of bearings at the shoulder of mill rolls. Models 64 and 82 are applied to large shafts at normal or high speeds . . . ideal for protecting bearings on back-up and work rolls. Model 53 withstands temperatures up to 250°F at normal or high speeds . . . recommended for table rolls. Where equipment can't be dismantled easily, Models 21 or 23 Split-KLOZURES are the choice.





Like Jones & Laughlin, many of the large steel producers are enjoying the advantages of Garlock KLOZURE Oil Seals. For instance, all KLOZURES are oil and grease resistant . . . impervious to water, mild acids, alkalies . . . non-abrasive . . . withstand temperatures from −40°F to +250°F. For extreme conditions, Garlock furnishes sealing elements resistant to practically any fluid, and serviceable as high as +500°F.

Enjoy these same benefits. Talk to your local Garlock representative about high-quality KLOZURE Oil and Grease Seals. Call him at the nearest of

GARLOCK

Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for KLOZURE Catalog 30. The Garlock Packing Company, Palmyra, N. Y.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*Registered Trademark

DREVER

ROLLER HEARTH *bright annealing* FURNACES

Installed at the plant of Sawhill Tubular Products, Inc.

Shown above:

Controlled Atmosphere Furnace, Radiant Tube, Gas-Fired

Capacity, 3,000 #/hour

Alloy Tubing ⅛" O.D. to 2½" O.D.

Overall, 176 ft. long x 7'-6" wide

Also Available:

Gas or Electric Furnaces for Stainless Steel Annealing with or without Controlled Atmosphere

For carbon and alloy steel parts bars or tubing

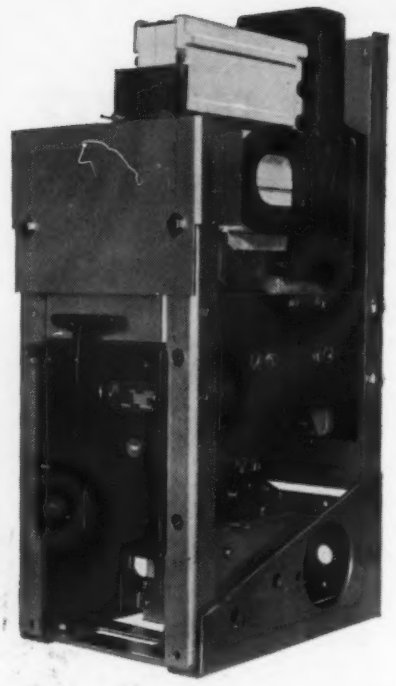
DREVER COMPANY

RED LION RD. & PHILMONT AVE.
BETHAYRES, PA.

Engineering and Manufacturing Facilities around the World through Associates in France, Great Britain, Germany, Italy and Japan

41

The d-c breaker you can buy today that won't be obsolete tomorrow



Stationary type single-pole FB breaker in 1200 amp rating with manual stored energy closing.

Actually this new-design model FB circuit breaker from I-T-E is somewhat of a phenomenon in its field. Of all breakers available for direct current, this is the only one that really makes use of today's modern materials and up-to-date knowledge of circuit breaker design. You might say it's the only modern d-c circuit breaker on the market today.

HIGH SPEED

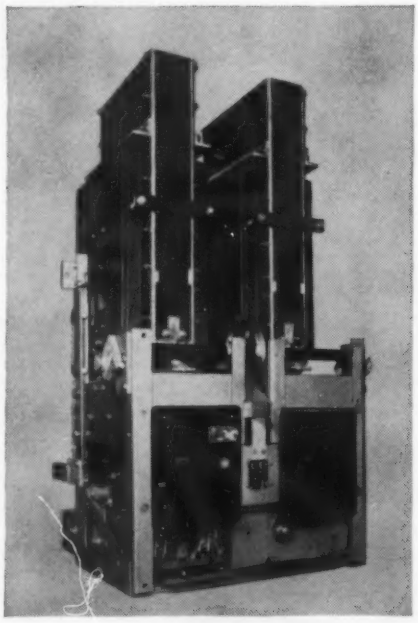
In today's high-capacity d-c circuits, you *need* a high-speed breaker. Otherwise you risk thermal or mechanical damage to equipment—such troubles as commutator flashover in rotating equipment or arc-back damage to your rectifiers. Many circuits today still have semi-high-speed breakers that don't give adequate protection. At the time they were installed they may have been the best available. Or else high-speed breakers were too expensive. That isn't true with the FB. Without paying a premium price, you get high-speed operation. Current limiting action occurs *within 6 milliseconds*. And the breaker may be safely applied to 1000 volt d-c circuits having a rate of rise of 15 million amperes per second. So the FB breaker can be used with confidence in practically all d-c circuits.

COMPACT SIZE AND LIGHT WEIGHT

Probably the most obvious difference between the new FB breaker and some of the old-design models still being sold is the greater compactness. This is one of the direct results of modern materials and technology. I-T-E engineers have given you actually superior circuit protection in less space. And the use of modern materials has shaved off many pounds of weight. Because of this they are now available in general-purpose enclosures. In addition, such new-design details as tilting arc chutes, elimination of flexible connectors, and exclusive drawout construction make this the easiest-to-maintain d-c circuit breaker you ever saw.

AVAILABLE IN 1 OR 2 POLES

If you are operating a single-wire grounded system, a single-pole circuit breaker arrangement will suffice. But suppose you are operating a 2-wire, ungrounded system. Then a 2-pole circuit breaker is desirable. And only the I-T-E model FB offers it. This is real 2-pole construction, with both poles fully integrated mechanically and electrically for simultaneous opening and closing under all conditions.



Drawout type 2-pole breaker in 6000 amp rating, electrically operated.

REALLY FUNCTIONAL MECHANICAL ADVANCES

Who but I-T-E would be first to give you an advance such as manual stored energy closing in a d-c circuit breaker? No slow burning of contacts with the FB. It closes in roughly 1/12 to 1/6 second for greater safety and longer contact life. You have your choice of either manual or electrical closing. The motor-operated closing mechanism draws only 5 amperes—a great advantage over the usual 50 amperes required by solenoids. Precision construction typical of I-T-E equipment, coupled with drawout design, permits complete interchangeability of breakers and parts in breakers of equal rating.

REPLACE NOW

There's questionable economy in trying to stretch out the life of old equipment that can mean costly downtime and inadequate protection. The wiser move is to replace now with new-design model FB breakers that are far ahead of the field. Models in capacities from 1200 through 12,000 amperes continuous and 1000 volts d-c. Write for the new detailed and illustrated Bulletin 4601-1A. I-T-E Circuit Breaker Company, Dept. SW, 1900 Hamilton St., Philadelphia 30, Pa.

I-T-E CIRCUIT BREAKER COMPANY

FELLER ENGINEERING CO.

presents

SCHLOEMANN

"Growing" rolling mills

It is not always possible to plan complete new rolling mill installations for maximum output. From the point of view of economy it is often necessary to modernize existing plants and enlarge them or to construct new plants in stages, so as to adapt oneself to available means or to meet later the demands of a slowly growing market. Much experience is required to find a solution to problems arising in this connection and to ensure a high degree of economy until the entire plant has been built. SCHLOEMANN is at present building four rolling mill plants for steel and non-ferrous metals, which provide for construction in stages. An example is given in the following:

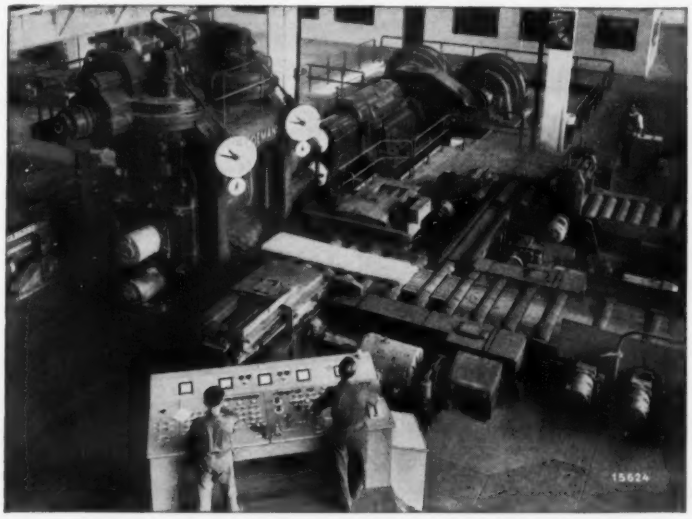
Stage 1: A two-high reversing mill for hot and cold rolling of non-ferrous and light metals.

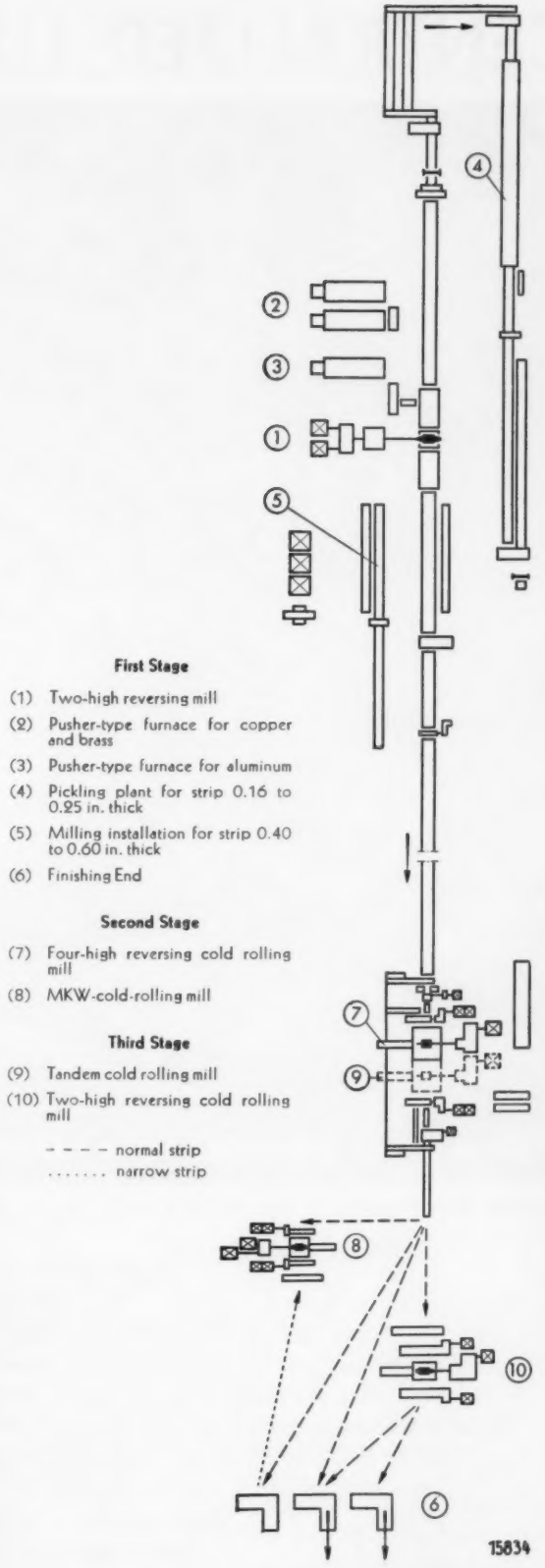
Stage 2: The existing two-high reversing mill is now used only for hot rolling, so a four-high reversing mill is added for intermediate cold rolling, and a MKW-type cold rolling mill for finishing of light guage strip and temper rolling of all strip.

Stage 3: The extension of the four-high reversing mill into a tandem mill and the addition of a two-high cold rolling mill for temper rolling.

Stage 4: The hot rolling mill and cold rolling mills are used only for the rolling of copper and brass and a separate mill is put up for the rolling of aluminum.

On this two-high reversing mill plates of copper, aluminum and their alloys are rolled into strip. In the first stage of construction, the mill serves for both hot and cold rolling.




First Stage
(1) Two-high reversing mill
(2) Pusher-type furnace for copper and brass
(3) Pusher-type furnace for aluminum
(4) Pickling plant for strip 0.16 to 0.25 in. thick
(5) Milling installation for strip 0.40 to 0.60 in. thick
(6) Finishing End
Second Stage
(7) Four-high reversing cold rolling mill
(8) MKW-cold-rolling mill
Third Stage
(9) Tandem cold rolling mill
(10) Two-high reversing cold rolling mill
– – – – normal strip
..... narrow strip
15834

Layout of a hot and cold rolling mill being erected in several stages.

FELLER ENGINEERING CO., 1161 EMPIRE BUILDING, PITTSBURGH 22, PA.

TRABON®

CENTRALIZED LUBRICATING SYSTEMS

Trabon protects critical bearings at Sharon Steel

Trabon design permits the use of smaller piping and tubing plus quality fittings — a potent force for leak prevention.

1,040 bearings on the United 44" x 104" Blooming and Slabbing Mill at Sharon Steel are lubricated precisely **and positively** by Trabon Centralized Lubricating Systems. Searing heat and tremendous shock loads put a premium on reliable lubrication. Trabon was the answer. Each bearing gets an exact pre-determined amount. And because of Trabon's patented progressive valve operation there is no possibility of skipping or underlubrication. And most important of all — a single **central warning** signal at the control point telegraphs "trouble" in case of blockage **anywhere** in the system. Using "original container" 400-lb. H-430 Barrel Pumps, eliminating transfer and spillage of lubricant, Trabon Systems serve approach tables, manipulators, shear, scarfer, ingot transfer cars, slab and blooming mill, slab transfer and slab piler at Sharon. Write today for more information on Trabon — the **modern** centralized system that gives you **central warning** as well as central pumping. Remember — Trabon is the **positive** system!

"*Centralized*" OIL AND GREASE SYSTEMS "*Meterflo*" CIRCULATING OIL SYSTEMS "*Meter-Mist*" OIL SYSTEMS

Trabon® **Trabon Engineering Corporation** 28785 Aurora Road • Solon 39, Ohio

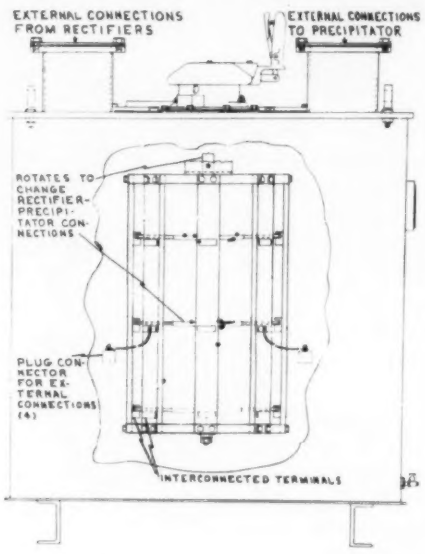
Equipment News...

HIGH VOLTAGE SWITCH

Δ Buell Engineering, Co., Inc., has announced a compact new high-voltage switch especially designed for distributing power from rectifiers to the electrodes of electrostatic precipitators. The new switch may also be used with other types of equipment having high voltage-low current characteristics.

The switch is a multi-deck rotary type designed to operate in all types of insulating oils. It may be housed in its own compartment, in which case it occupies about 1 cu yd of space, approximately one-fourth the space required by an equivalent air switch. It may also be immersed in the same compartment as the transformer-rectifier, in which case the transformer-rectifier compartment is lengthened or widened approximately two ft.

Compact design results in a lower-cost component, reduced space requirements when located indoors, and less congestion in confined quarters when installed on the precipitator roof. The totally enclosed switch offers the further advantages


EXTERNAL CONNECTIONS FROM RECTIFIERS
EXTERNAL CONNECTIONS TO PRECIPITATOR
ROTATES TO CHANGE RECTIFIER-PRECIPITATOR CONNECTIONS
PLUG CONNECTOR FOR EXTERNAL CONNECTIONS (4)
INTERCONNECTED TERMINALS

of freedom from corrosive effects of atmospheric elements and freedom from possible deposits of airborne dusts. A greater safety factor is also achieved as personnel have no opportunity to come in contact with live parts.

To meet the unique power requirements peculiar to electric precipitators—extremely high voltages and extremely low currents—the switch is conservatively engineered for 100,000 volts and 1 ampere. Switch action is of the double-blade type and large surface contacts withstand brief, but extremely steep, feedbacks inherent in precipitator operation. The switch can be operated under load if necessary.

Structural members of the new switch are of epoxy resins. The standard switch consists of a three-deck arrangement as illustrated. When used with a system having two rectifiers and two precipitator units, it could be wired so that either of the rectifiers could be connected to either of the precipitator units; so that one rectifier could be connected with one of the precipitator units, the remaining rectifier being grounded; or so that both rectifiers are grounded.

Provisions are made for use of safety-key interlocks, and in order for the switch to distribute power to a given electrode, a key must be in its respective socket at the switch. Then, when a person wants to enter the precipitator housing, this key is required to unlock the entrance door, and to obtain the key it is necessary to turn the switch to an "off" position.

NEW SCRAP CHARGING PROCESS SLATED FOR J&L

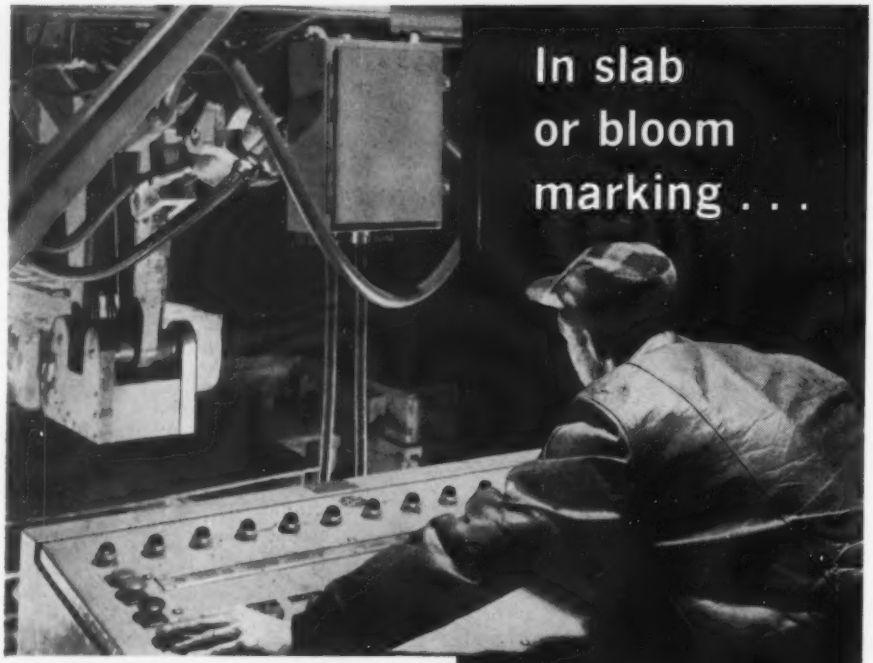
An innovation in scrap charging is being built for the Pittsburgh Works of the Jones & Laughlin Steel Corp. Shown examining a model of the unit are the following: S. W. Stouffer, assistant director of construction and maintenance, A. A. Archibald, vice president—engineering and plant, P. H. Devaney, general manager of production, A. T. Lawson, vice president—production, W. P. Getty, assistant vice president—production, and Sam Calderone the inventor.

CUTTING TORCH

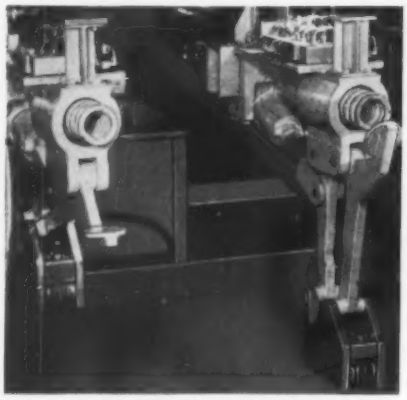
Δ A rugged duty cutting torch with flow capacity which enables it to cut 24-in. steel has been introduced by Smith Welding Equipment Corp. under the trade name of "Tuf-Tony."

Primarily designed for heavy cutting under all conditions, this versatile torch adapts to a wide variety of less demanding applications by use of different "slip-in" tips.

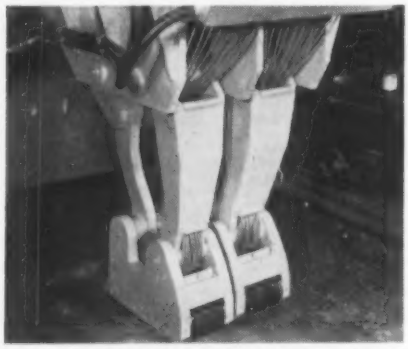
An exclusively designed feature of the unit is an oxygen control valve which permits gradual introduction of cutting oxygen. This



Operator presses button to actuate stamping cycle or change characters—installed at a transfer table.



Twin units for automatic consecutive numbering of 2½" bar billets—for installation along edge of cooling bed.



Double-headed Slab Marker with 18 stamping wheels, photographed during testing—for installation over a roller line.

CUNNINGHAM
HAS THE
EXPERIENCE

14 UNITS IN SERVICE
. . . MORE ON ORDER

Under constant development for more than 12 years, Mecco Safety Slab Markers are the industry's most advanced—*the most thoroughly service-proved*, by a margin of hundreds of thousands of tons.

We'll gladly consult with you on any phase of steel industry marking. *May we send technical bulletins on Slab Markers?*

Mecco SAFETY MARKING TOOLS

M. E. CUNNINGHAM CO.
1041 CHATEAU STREET
PITTSBURGH 33, PENNA.

reduces slag spray and facilitates control in such processes as piercing, rivet washing and heavy cutting. The torch is equipped with an over-or-under cutting lever which is easily reversed for operator preference.

Large gas tubes and a high pressure valve port permit the flow of the volumes of gas required for heavy cutting.

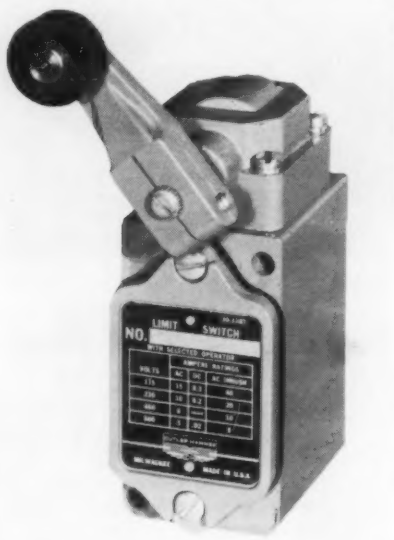
Engineering features which contribute to ease of maintenance and safe performance include: replaceable hose connections which are not integral with the forged butt; stainless steel needle valves which seat positively against brass; and "O" ring seals which prevent gas leakage.

Extensive durability tests have demonstrated its functional ruggedness, yet the torch is light (3 lb 10 oz) and well balanced. It has a slip-proof grip with adhesive handholds. It is available in lengths of 21 in. and 36 in., with heads of 75 deg and 90 deg.

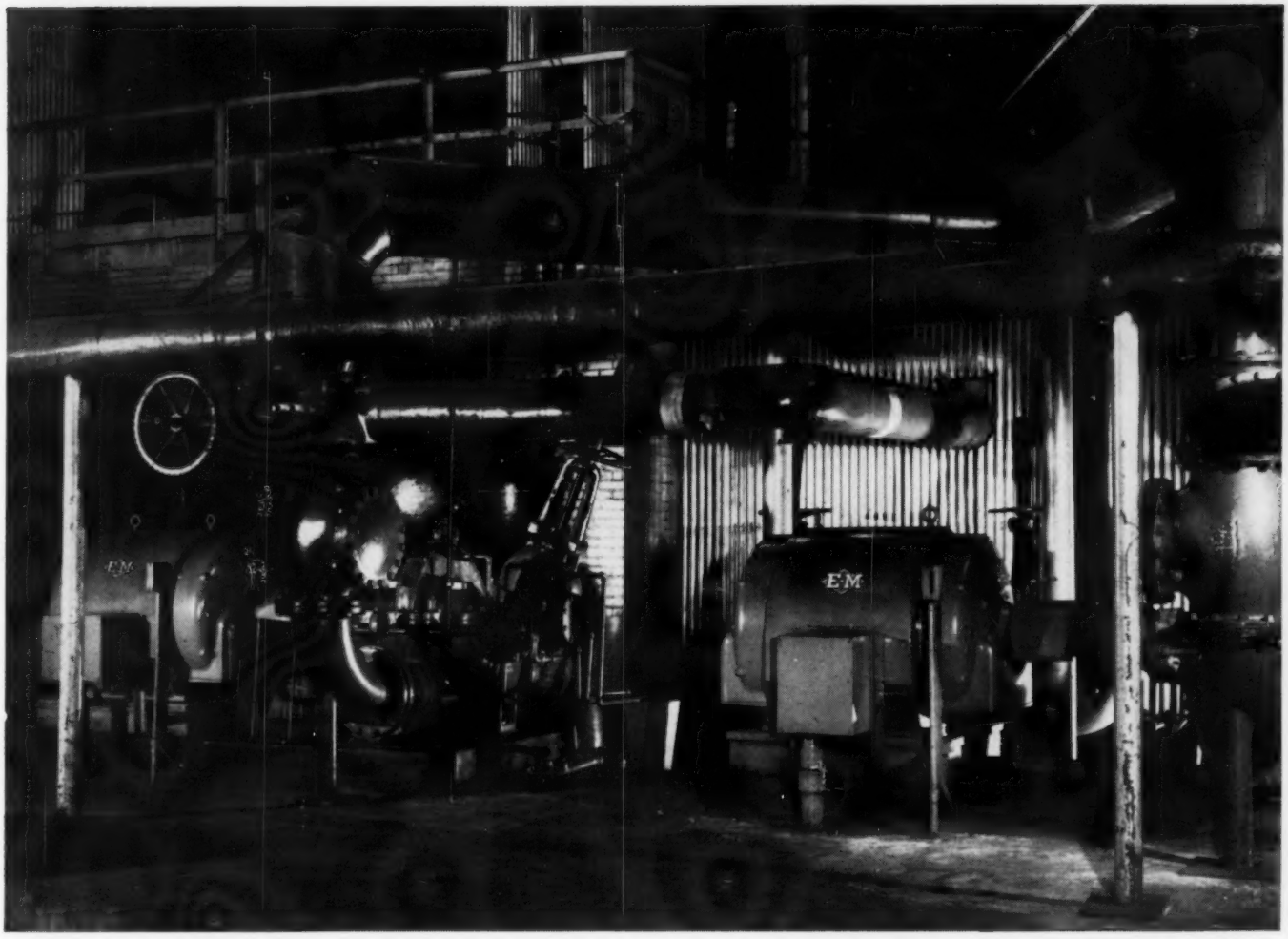
LIMIT SWITCH

△ A completely new family of limit switches has been introduced by Cutler-Hammer, Inc.

Specifically designed for applications on high-speed, precision production machines, the limit switches are truly oil-tight—ideal for installations where high impacts and adverse environmental conditions are recognized as major factors in "standard" limit switch failure and subsequent machine downtime.



Each switch is sealed to positively check seepage of oil, coolants, moisture and abrasive grit. External seals are located at the operating



Jones & Laughlin Steel Corporation enjoys low maintenance costs on large motor drives

● Safeguarding motor operation in a steel mill is an important factor in the mill's over-all profitable operation. Motor shut down means costly maintenance projects and large production losses. Bearing failures and winding burn outs are no longer considered inevitable, and today's mill operators who are interested in continuous high-level production are taking advantage of modern motor design to insure against motor failure.

The two 400 hp, 1450 rpm, splash-proof E-M Squirrel-Cage Induction Motors above show how Jones & Laughlin Steel Corporation engineers use modern motor design to protect against motor outage. These motors, which drive centrifugal pumps supplying water to three hot strip-mill furnaces at the Pittsburgh works, have given year-in, year-out service with only routine bearing lubrication and inspection. E-M *Protective Construction* keeps water and foreign material out of vital parts, so essential to uninterrupted, trouble-free operation.

And remember, *Protective Construction* means more than physical shielding of windings and bearings with splash-proof or other protective enclosures. It includes the E-M "know-how" of motor design and special attention to the smallest details of construction. Here are some of the important features in E-M *Protective Construction:*

1. Windings custom designed for the application, repeatedly processed to keep moisture out.
2. Coil ends methodically lashed to heavy rings to prevent movement during repeated starting surges.
3. Bearings precision engineered and processed for cool, long-life service.
4. And rotors of practically indestructible cage construction, accurately balanced for vibration-free operation.

For your next *special* motor application call on your local E-M sales engineer for helpful counsel. Let him show you how E-M *Protective Construction* can help keep your maintenance costs low on large motor drives. And write the factory for E-M Foto-Facts No. 16, showing other modern motor applications in a modern steel mill.

ELECTRIC MACHINERY MFG. COMPANY
MINNEAPOLIS 13, MINNESOTA

E-M

1300-TPA-2167

Specialists in making motors do **EXACTLY WHAT YOU WANT THEM TO**

shaft bearing and between the cover plate and contact assembly. An internal seal between the operating head and switch base provides double insurance against the entrance of liquids into the contact cavity.

Contacts are enclosed but visible. This is achieved through the use of a new thermoplastic material which guarantees positive contact visibility.

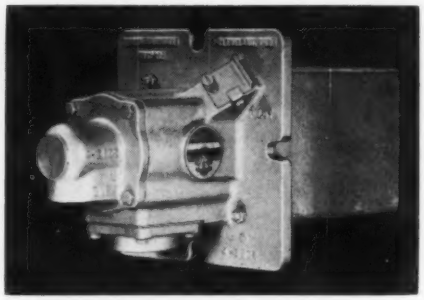
Available in both surface type and flush type mountings, the switches are calibrated to control tolerances producing identical operation of all switches. Parts and assemblies can be interchanged from switch to switch or replaced without affecting subsequent accurate performance.

For further field flexibility, the manufacturer also has available 14 different operating heads (including side and top pushbuttons, vertical and horizontal push rollers, adjustable and fixed roller levers). Operating heads may be mounted in any of four positions, 90 deg apart. Rotary levers may be positioned anywhere through a 360 deg circle. Rotary lever type limit switches provide field selection in any of three operating sequences of the contacts: clockwise; counterclockwise; clockwise and counterclockwise.

GAS BURNER

△ Uniform furnace temperature for heat treating processes, regardless of uneven loading, may be obtained by using excess air with North American Manufacturing Co.'s new Series 4423 Sealed-in Nozzle Mix Gas Burner. This uniform temperature is achieved by lowering gas intake while maintaining an excess air rate.

Simplified design, combining a rugged cast-iron mounting plate and burner body into one piece with nine in. burned ceramic tile attached, provides solid construction. Provision is also made for a flame monitoring device to assure flame safety. Either an interrupted or constant pilot may be used.



The largest size burner (1½ in.) can have its fuel input turned down from 431 cfhr to 52 cfhr of natural gas when using 16 psi air pressure. This results in an available heat turndown ratio of 150 to 1 in a 675 F furnace. The hot mix temperature then issuing from the tile is less than 700 F and the flame is entirely in the tile.

This burner is available with air pipe sizes of ¾ in. to 1½ in. A range of 70,800 to 431,000 Btu per hour is possible at an air pressure of 16 psi.

INDUCTION MOTORS

△ The Lincoln Electric Co. has announced the expansion of their line of three phase, squirrel-cage induction motors to include sizes from ½ to 125 hp. "Multiguard" protection, a specially compounded thermo-setting plastic used to encapsulate and impregnate the stator, will be included on all motor sizes.

SUPERIOR
CARBON
BRICK
FOR
◀ Blast furnace linings
◀ Blast furnace run-out troughs
◀ Cupola linings
◀ Steel pickling tanks
Standard sizes and shapes • Tested performances
Competent technical service • Superior chemical and metallurgical characteristics • Graphite brick also available.
May we give you a quotation?
ELECTRODE GLC® DIVISION
GREAT LAKES CARBON CORPORATION
18 EAST 48TH STREET, NEW YORK 17, N.Y. • OFFICES IN PRINCIPAL CITIES

NEW

ONE PIECE BLOW PIPE

(and seat)

HIGHER SAFETY FACTOR

INCREASES EFFICIENCY

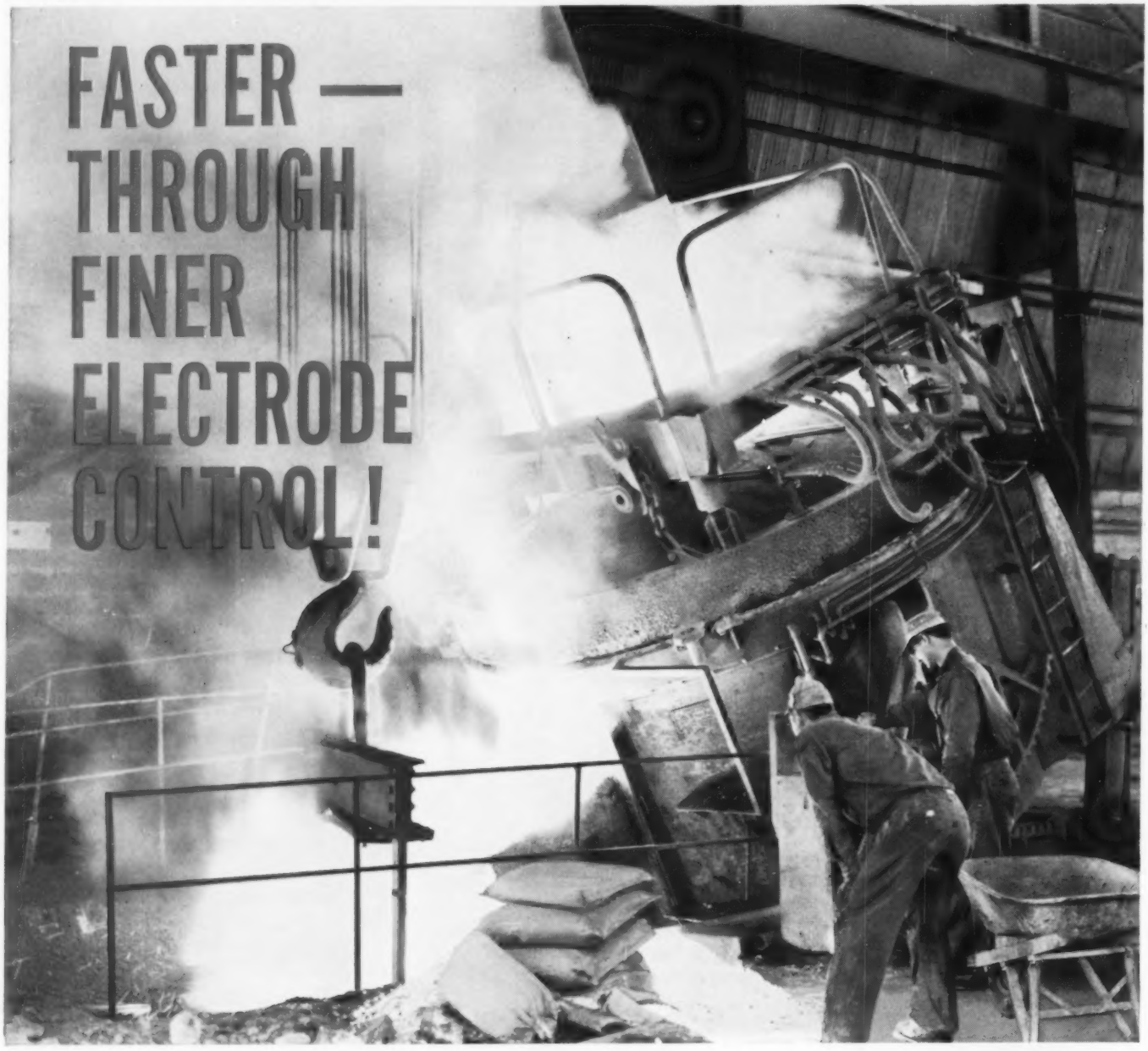
ELIMINATES COSTLY BREAKDOWNS

One of the latest developments in blast furnace components . . . A ONE PIECE CENTRIFUGALLY CAST HEAT RESISTING ALLOY BLOW PIPE AND SEAT. Formerly cast in three sections and welded; the new one piece Cleveland Alloy Method decreases costly break-downs due to weld burn-outs. Designed to withstand increased temperatures. Refractory insulation liner optional. Cleveland Alloy Blow Pipes and Seats can be produced in a range of analysis including columbium and nitrogen stabilized alloys.

Cleveland Alloy Castings, Inc.

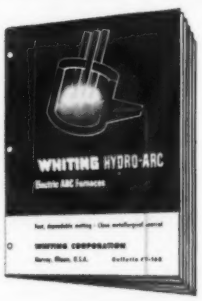
20303 FIRST AVENUE • BEREA, OHIO

FLORIDA STEEL CORP., TAMPA, SELECTS HYDRO-ARC ELECTRIC FURNACE FOR FLORIDA'S FIRST STEEL MILL!



Hydro-Arc electric furnaces, from Whiting, give you full-time arc efficiency, faster heats, more wattage turned into melt, lower electrode consumption, virtually no electrode breakage. Arc adjustment is instantaneous. Mechanical lag? Almost totally eliminated by non-stop, non-reversing electrode motors plus vital air counterbalance. Here's Whiting's new concept in low-cost electric melting—new, yet fully proven for your benefit in steel mill after steel mill. Look into Hydro-Arc now!

Get Details in Hydro-Arc Catalog No. FY-168, or ask a Whiting furnace engineer to call. No obligation. *Whiting Corporation, 15655 Lathrop Avenue, Harvey, Illinois.*



See Our Catalog in SWEET'S

87 OF AMERICA'S "FIRST HUNDRED" CORPORATIONS ARE WHITING CUSTOMERS

ELECTRIC FURNACES

WHITING

MANUFACTURERS OF CRANES; TRAMBEAM® HANDLING SYSTEMS; PRESSUREGRIP; TRACKMOBILES®; FOUNDRY, RAILROAD, AND SWENSON CHEMICAL EQUIPMENT

In addition to increasing motor sizes, Lincoln has introduced a number of design modifications which further improve its performance. The die cast aluminum rotor is supported by doubly shielded Super Conrad type bearings. The bearing and fabricated steel end bell design permit operating the motor with the shaft in either the horizontal or vertical position. Bearing life is increased with a sealed housing having a reservoir for grease stor-

age and facilities for regreasing. A positive housing seal preventing entry of destructive contaminants is achieved by mounting a neoprene slinger on the shaft against the exterior side of the end bell and fastening specially designed dust caps to the inner face of the housing.

The entire motor including the fabricated steel frame and end bells, and cast aluminum rotor is coated inside and out with a vinyl based primer and an acid resistant paint. This insures excellent motor performance even under conditions that cause rotor freezing on unprotected open type motors.

VOLTAGE RECORDER

△ A new narrow-range a-c voltage recorder for utilities and industrial plants demanding close, accurate voltage checks is now available from General Electric Co.

The instrument provides a continuous record of voltage fluctuations between 110 and 130 volts on a $10\frac{3}{4}$ in. calibrated scale and strip-chart. Accuracy is plus or minus 0.25 per cent of mid-scale voltage.

In operation, the recorder uses the stable voltage characteristics of a silicon diode to compare forward and reverse half-cycles of the input voltage. This produces an average d-c voltage proportional to the input RMS voltage, which is then measured using a potentiometric null-balance recorder mechanism.

The recorder is available for both 50- and 60-cycle systems. Chart speeds ranging from $\frac{1}{2}$ to 360 in. an hour and response times from one to 24 sec can be provided.

Ease of maintenance is aided by a hinged mechanism panel that swings out to allow access to all components within the instrument. Components are isolated by function, and are easily accessible for replacement. Printed circuit boards and plug-in components are incorporated to facilitate servicing.

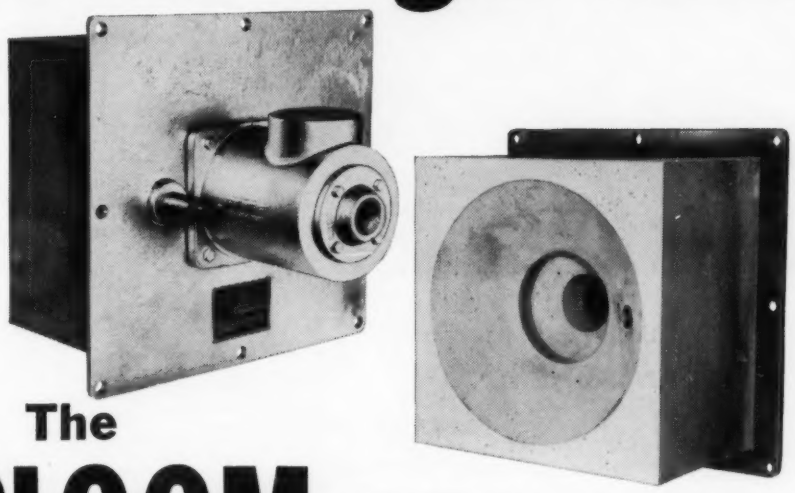
A wide variety of accessories is available, including marker pens, internal illumination, and alarm switches. Adaptable for either surface or semi-flush mounting, the recorder is $17\frac{11}{16}$ in. wide, $16\frac{3}{16}$ in. high, and $17\frac{1}{16}$ in. deep.

BASIC ROOF

△ The George P. Reintjes Co. has announced, the development of a newly designed basic roof for open hearths and similar furnaces.

It is a semi-suspended type roof, the refractory material being connected to supporting steelwork above the roof arch. This steel is

Focus High Heat

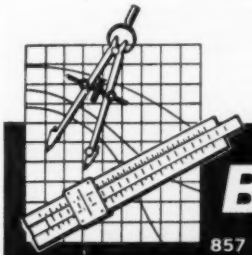


The BLOOM HTR BURNER

The Bloom High Thermal Release Burner can be located in a furnace roof or wall to give the operator the temperature he needs for a given area. Maintenance on this burner is minimized, since alloy or cast iron parts aren't exposed to high temperature.

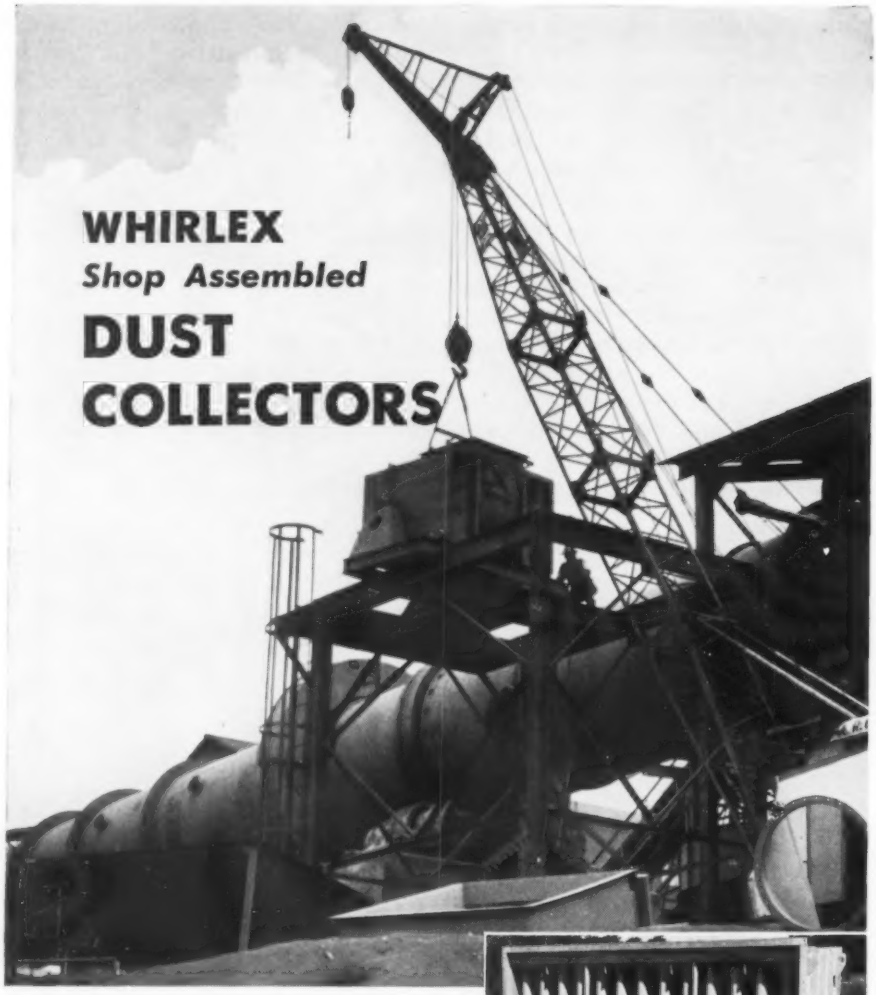
Applications include:

Tube Upsetting
Continuous Strip Pre-Heating, Annealing, Coating, and Drying
Batch type Forging
Aluminum Chip Melting
Meta-Silicate Melting



BLOOM ENGINEERING COMPANY, INC.
857 WEST NORTH AVENUE • PITTSBURGH 33, PENNSYLVANIA

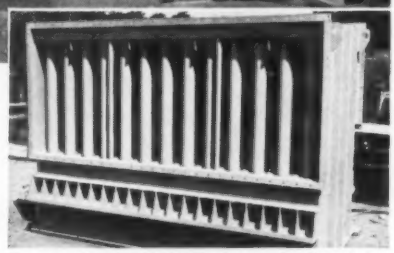
ENGINEERING • EQUIPMENT • SERVICE



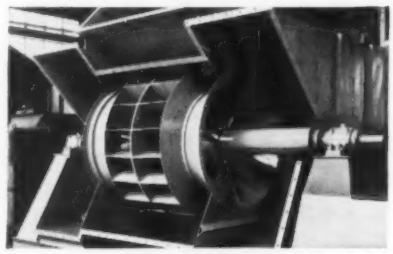
. . . Cut Erection Costs to a Minimum

This highly efficient Whirlex collector is completely shop assembled and need only be bolted in place at the erection site. Rigid shop inspection assures a "gas-tight" installation thus eliminating the opportunity of error at the job site.

A Whirlex Shop-Assembled Dust Collector may be the answer to your problem. Write for more complete information.



Whirlex Dust Collector completely fabricated and ready for shipment



Whirlex FD and ID fans are designed for heavy, rugged duty

Fly Ash Arrestor
CORPORATION
203 North 1st. Street • Birmingham, Ala.

Dust Collectors • Induced Draft Fans
Forced Draft Fans • Exhaust Fans
Self Supporting Stacks • Duct Work

FLY ASH WHIRLEX ARRESTOR

pivoted on either end and is loosely hinged over the center of the roof arch.

Coil springs operating under compression are connected to this movable steel work and exert a predetermined lifting force to the refractory arch. Since this method of applying a controlled lifting force to the roof arch decreases skew line pressures to as low as 20 per cent of the pressures encountered in a conventional sprung arch, it has been termed a low pressure arch.

This type roof using burned metal-cased basic refractory material has been in service for over 300 heats in an eastern steel plant.

COIL HANDLING MAGNET

△ A multi-polar coil handling magnet especially designed for use in mills, fabricating plants, warehouses, etc., is announced by The Ohio Electric Mfg. Co.

Designated as Type CL Coil Handling Magnet, the unit is recommended for handling hot or cold strip coiled sheet steel. Maximum operating temperature is approxi-

mately 1000 F. It is offered in size ranges from 23 x 46 in. with lifting capacity of approximately 11,000 lb up to 62 x 62 in. size with a 70,000 lb lifting capacity for tightly wound coils under average conditions. Four intermediate sizes and capacities are available.

The magnet, permits safe, efficient handling of coils and minimizes surface damage. In addition, it permits maximum utilization of storage space since the magnet shape

(*Please turn to page 264*)

CUT GRINDING TIME...IMPROVE FINISH

WITH MIDVAC

Micro Lustre

VACUUM MELTED FINISHING ROLLS

Made from consumable electrode vacuum melted Midvac Steels these rolls offer qualities unsurpassed in cleanliness and ductility by any metal finishing rolls. They have a super uniformity of fine grain structure, maximum freedom from defects and non-metallic inclusions.

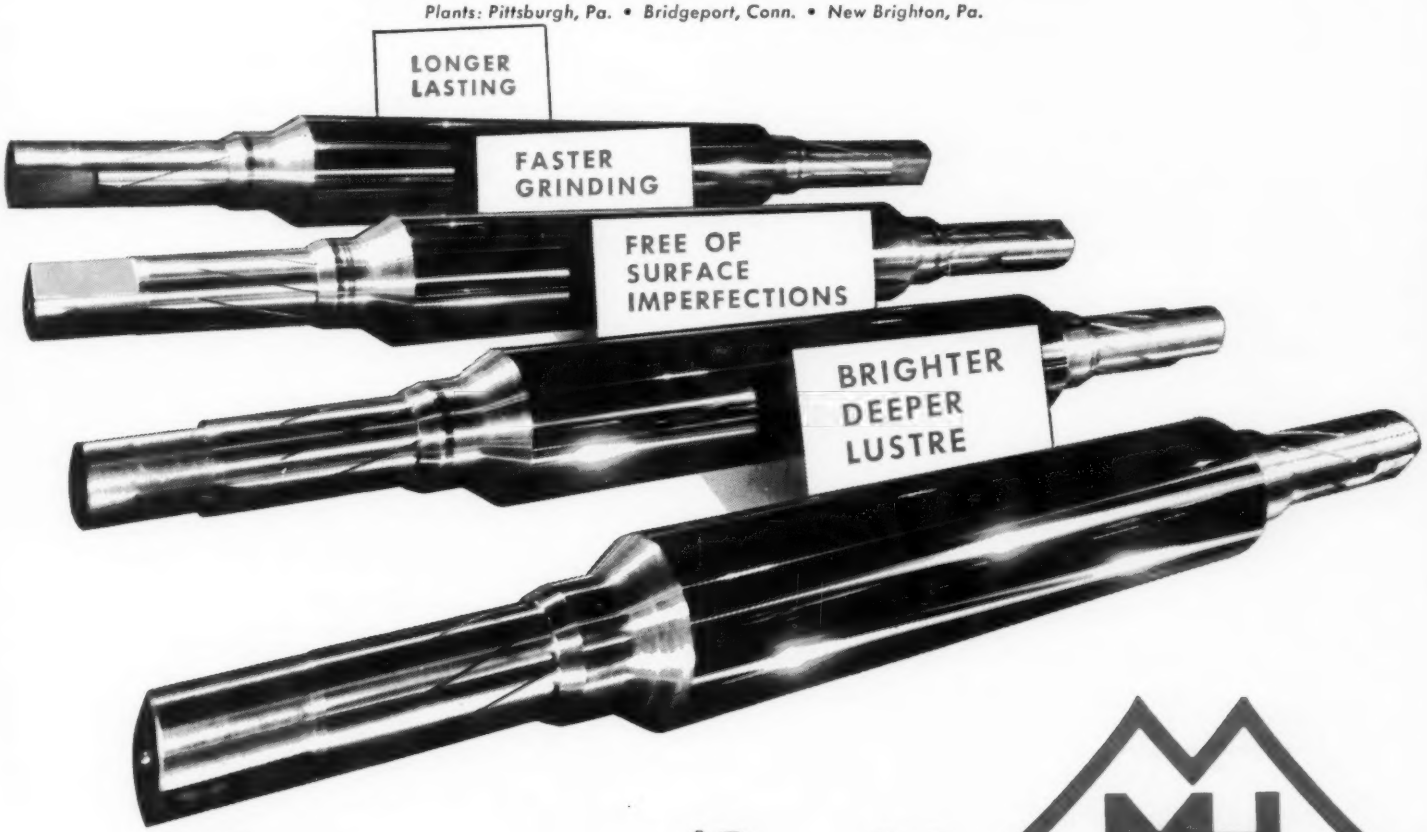
Midvac Rolls are precision ground to a deep, black, Micro-Lustre finish . . . assure rolling of stainless steel, foil and precious metals free of surface imperfections. The super uniformity throughout has resulted in rolls lasting twice as long between grinds. The deep Micro-Lustre grain structure makes it possible to cut grinding time in half.

Improve product quality and get more footage out of every roll — specify Midvac Rolls on your mills. Midvale-Heppenstall also makes forged rolls for rolling steel and non-ferrous metals, paper, plastics and rubber.

MIDVALE-HEPPENSTALL COMPANY • NICETOWN, PHILADELPHIA, PA.

SUBSIDIARY OF HEPPENSTALL COMPANY, PITTSBURGH, PA.

Plants: Pittsburgh, Pa. • Bridgeport, Conn. • New Brighton, Pa.



Midvac Rolls

MH

NOW! Fuses that...

Safely interrupt fault currents up to 200,000 amperes...

Limit fault current to very low values

Hold 500% load for minimum of ten seconds

Buss Low Peak fuses can completely revolutionize the protection of the entire electrical system.

Protect Mains, Feeders, Branch Circuits, Motors, Controllers, Switches—no matter whether the fault current is 1,000 amperes, 25,000, 100,000—or as high as 200,000 amperes.

Reduce stresses and prevent damage to Panel-boards, Switches, Motor Controllers—other circuit components—because let-thru fault currents are limited to exceptionally low values.

Prevent work stoppages, lights out, waste of time and money—because long time-lag keeps them from opening needlessly on motor starting currents or other harmless overloads.

Permit increasing interrupting capacity and current limitation on present system at minimum cost.

Before designing a new installation— or modernizing old installations—

GET ALL THE FACTS

Knowledge without action is of little value—but ACTION NOW may save you money—increase operating efficiency and reduce electrical hazards to a minimum.

BUSS LOW-PEAK fuses fit standard Switches and Panel-boards and are available in N.E.C. sizes from 15 to 600 amperes in both 250 and 600 volt ranges.

Write for BUSS LOW-PEAK Bulletin Now . . . or use coupon.

Bussmann Mfg. Division
McGraw-Edison Co.
St. Louis 7, Mo.

BUSS
Low-Peak
FUSES

Bussmann Mfg. Division, McGraw-Edison Co.
University at Jefferson, St. Louis 7, Mo.
Please send BUSS Low-Peak Fuse Bulletin LPS.

Name.....

Title.....

Company.....

Address.....City.....State.....

ISE-460

CAR HEARTH FURNACES

FOR

HEAT TREATING
STRESS RELIEVING
ANNEALING
HOMOGENIZING
600°F TO 2500°F

DIRECT FIRED OR FORCED CONVECTION, OIL, GAS, ELECTRIC

R-S CAR HEARTH FURNACES are batch type furnaces with movable hearth for ease of loading and unloading. They can be designed to your specifications as direct fired units for temperature range from 1000° to 2500°F. or as forced convection units from 600° to 1600°F.

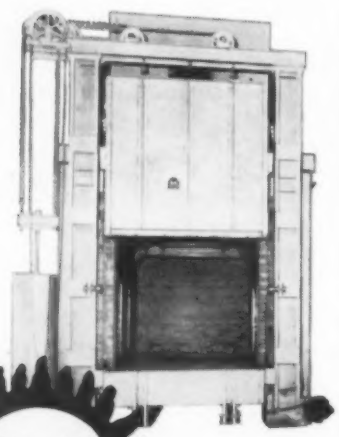
R-S CAR HEARTH FURNACES can be built to utilize oil, gas or electricity, whichever is the most economical for your plant. Whatever the charge weight, length or width required R-S engineers can design and build the furnace to meet your requirements most efficiently.

R-S CAR HEARTH FURNACES have proved themselves throughout the world. In foundries for heat treatment of steel and iron castings. In metal working plants for stress relief of weldments, annealing, normalizing, spherodizing and forging, or to heat for rolling, forming, or forging.

For full details on R-S Car Hearth Furnaces write to...

R-S FURNACE CO., INC.

NORTH WALES, PA.



R-S FURNACES

(*continued from page 260*)

is tailored to the coil with minimum overhang.

Magnet poles are located over the coil edges, thus providing an efficient flux path for maximum lifting power with minimum stray field so as to prevent attraction of small parts to the bottom of the coil. Elongated pole shoes distribute coil weight over a large area, further minimizing damage to the coil edges.

Magnets are of two or four pole construction, depending on size. Each pole is a separate magnet having its own coil, cast nonmagnetic housing and extended pole shoe. Adjacent poles are of opposite polarity.

Top case is a dynamo steel casting, consisting of heavy sections for long life under severe abuse. Coils are wound with strip copper, quinterra asbestos tape, mica insulated discs and rings bonded with high temperature epoxy resins for long life. Smaller size magnet CLI-23 is wound with glass covered magnet wire. Heavy alloy steel chain is provided consisting of four legs to insure level suspension and additional safety factor. Each pole is filled separately with nonremelting potting compound. Protective shield is formed around magnet and welded to the top case. Heavily insulated terminals and leads are supplied, and protected by lead shields and clamps. The terminal housing is easily accessible and made watertight.

A-C DRIVES

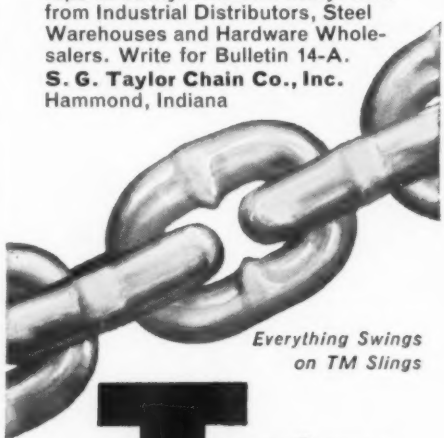
△ A new line of economical, adjustable-speed a-c drives, called Magnaflow, has been introduced by the Westinghouse Electric Corp. These drives are of the integral-unit construction, rated from ¼ to 100 hp. Larger drives with separate motor mounted on a bedplate are offered up to 700 hp liquid cooled. In addition, simple control modifications to provide a variety of speed operating functions are also available.

The electromagnetic drive is designed to apply adjustable speed power to conveyors, fans and pumps, winders and metal slitting and forming machines; it is used practically anywhere speed control is needed.

TOPS in SAFETY

TM Alloy Chain puts muscle in your safety record. A minimum breaking strain of approximately 125,000 lbs. psi . . . rugged stress-free links . . . controlled heat-treating, are a few reasons why TM Alloy Chain is tops in safety. Available everywhere from Industrial Distributors, Steel Warehouses and Hardware Wholesalers. Write for Bulletin 14-A.

S. G. Taylor Chain Co., Inc.
Hammond, Indiana



Everything Swings on TM Slings

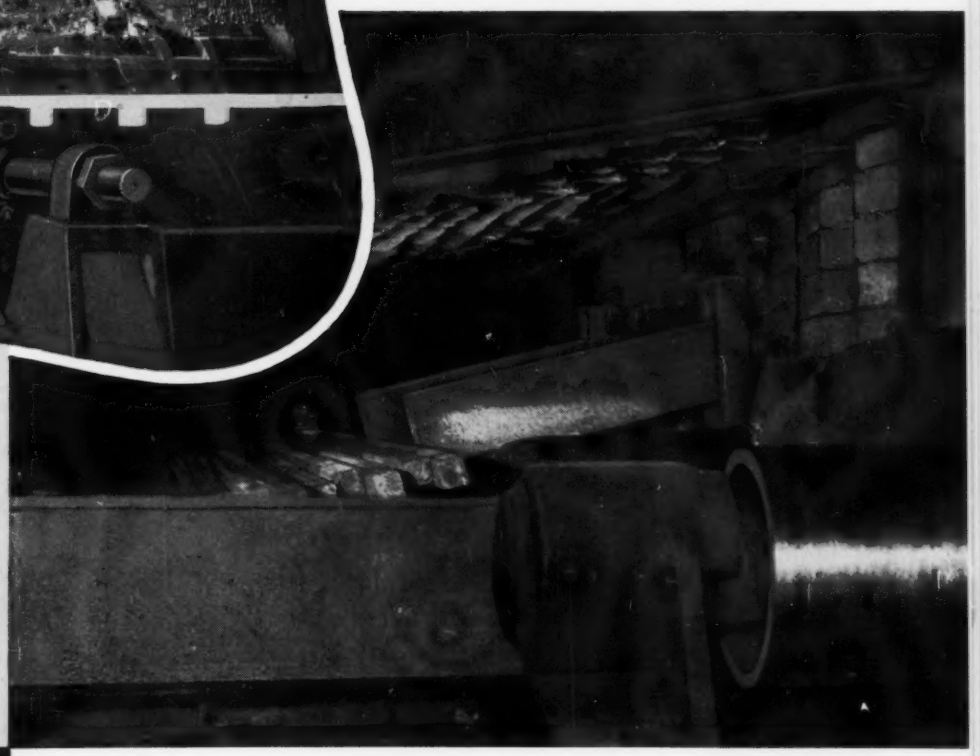
Taylor Made CHAIN SINCE 1873

TRANTINYL SKIDS AND PUSHER ARMS

serve high tonnage requirements at

ACME STEEL COMPANY

Riverdale, Illinois



ABOVE: Discharge or drop off end of furnace with slab transfer table in Acme #2 Mill.

RIGHT: Acme #3 Mill furnace installation of Trantinyl Skids and Pusher Arms.

Trantinyl #6 Alloy Dry Skids used in Acme furnace hearth.

Long-lasting, trouble-free performance proves TRANTINYL dependability in Acme furnace skid applications . . .

In Acme #2 Mill Trantinyl #6 Alloy Skids are operating at furnace temperatures up to 2500° F. They are giving from *14 to 18 months'* service as compared to *5 to 8 weeks'* service given by old types of skids. In Acme #3 Mill furnace, installations of Trantinyl #6 Alloy Skids in service over 5 years are still in usable condition. Trantinyl Pusher Arms, shown above, have been in operation more than 1½ years and are also in good usable condition.

TRANTINYL GUIDES THE STEEL INDUSTRY

Youngstown Alloy Casting Corporation

Youngstown, Ohio

G-

Sole Licensee to cast "TRANTINYL" for the Midwest, West and South: WAUNAKEE ALLOY CASTING CORP., Waunakee, Wis.

Predictable Performance

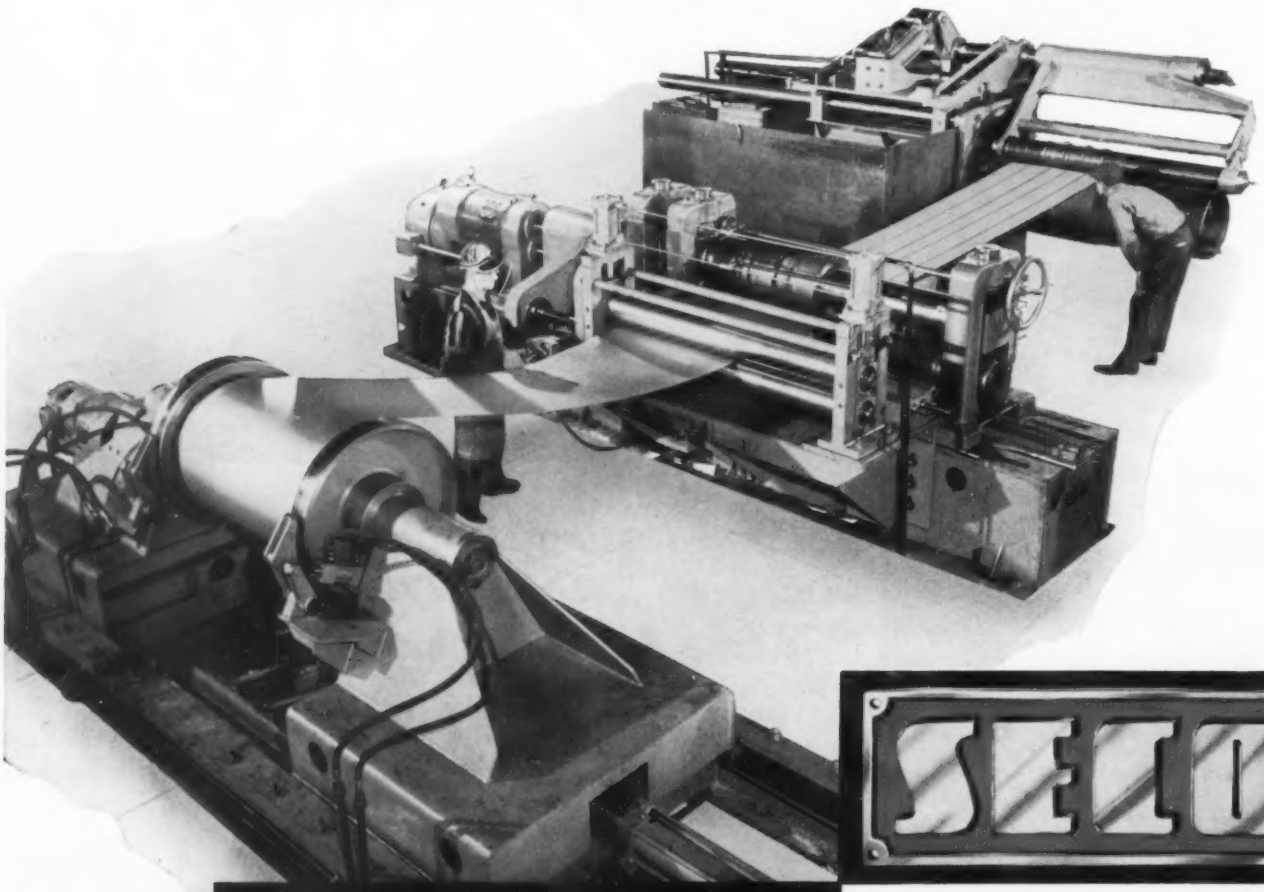
...is assured
Detroit Steel Corporation
with the installation of a

SECO **60" SLITTING LINE**

Availing themselves of SECO's facilities for custom building efficient slitting lines, the Detroit Steel Corporation, Detroit, Michigan, just recently installed this 60" Seco Slitting Line thereby assuring predictable performance. The entire unit, consisting of a cone-type Uncoiler, Slitter and Recoiler, was specifically designed and built by SECO for this customer.

Whatever your present requirements may be, call upon SECO's staff of trained sales engineers to assist you in planning for the present as well as your 'future' capacity.

Seco builds a complete range of slitting lines available from 12" to maximum strip widths.



SECO

STEEL EQUIPMENT COMPANY

P. O. BOX 737, WARRENSVILLE STATION
CLEVELAND 22, OHIO

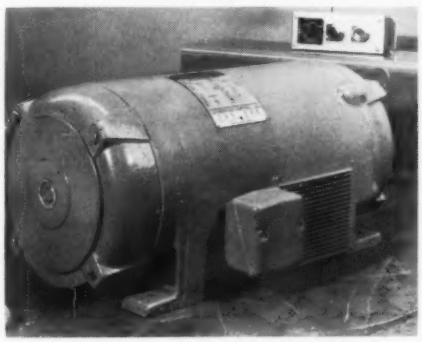
SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
- Combination Edging and Flattening Lines
- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
- Slitting Lines
- Multiple Strand Pull-out Rolls and Take-up Frames
- Strip Coilers (Up and Down Type)
- Traverse Reels for Narrow Strip
- Steel Coil Up-enders
- Scrap Ballers

Affiliated with Lee Wilson Engineering Co., Inc.

The drive can be set before or during operation to deliver any desired speed within its range. Not only can the speed be adjusted quickly and easily, but it remains adjusted. A built-in tachometer monitors the output speed and automatically corrects it, regardless of any change in load.

Each drive operates on a-c power; there are no brushes, commutators,



or slip rings to maintain. In addition, there are no friction members to wear, replace or adjust.

Another feature is the compactness of the control for this type drive. Standard excitation and regulator control for air-cooled drives up to 30 hp measures only 9¾ by 8¼ by 24¼ in. For higher horsepower units, the control is only slightly larger. Control units provide speed regulation accurate within plus or minus two per cent of top speed.

Because of the extremely small excitation requirements, the drives are adaptable to either electronic or magnetic amplifier excitation control. Moreover, many versatile modifications are available, such as electromagnetic braking, inching, threading, torque control, controlled acceleration, multidrive control, constant tension for winding, etc.

MAGNETIC PILER

Δ A magnetic piler and crane, now in operation at Northwestern Steel and Wire Co., Sterling, Ill., handles steel angles, channels, beams and plate faster and more efficiently than possible by any other means known to date.

The piler has complete facilities for nesting all structural products and piling all plate coming off the company's 20 in. rolling mill.

The new equipment makes possible a neater package and better strapping job than otherwise obtainable with conventional machinery. It also enables the company to provide faster service on deliveries, and pile up to one-third more steel in the same size package.

Although the equipment has not been run at full capacity, Northwestern estimates that it can pile up to 100 tons per hour in any of the four shapes and over a wide range of sizes.

Designed and built by Birdsboro Corp., the equipment consists basically of a magnetic piler and an 84-ft-span magnetic piling crane. Both the piler and crane are electrically interlocked.

Angles and channels are stacked in reversing rows on a nesting bed by means of a magnetic turnover device and the crane. Beams are conveyed to the table by the crane alone. Plate can be moved by the magnetic crane or, if there is any need to inspect both sides of the steel, it can be reversed by the magnetic turnover.

The piler equipment enables the company to make up lifts of practically any weight to customer specifications. Thus the mill will pile the industry-standard five-ton lifts, three-ton lifts, one-and-a-half-ton lifts and other packages of special weights to customer specifications.

Although the equipment is now remotely controlled by pushbutton, it is designed for fully automatic operation.

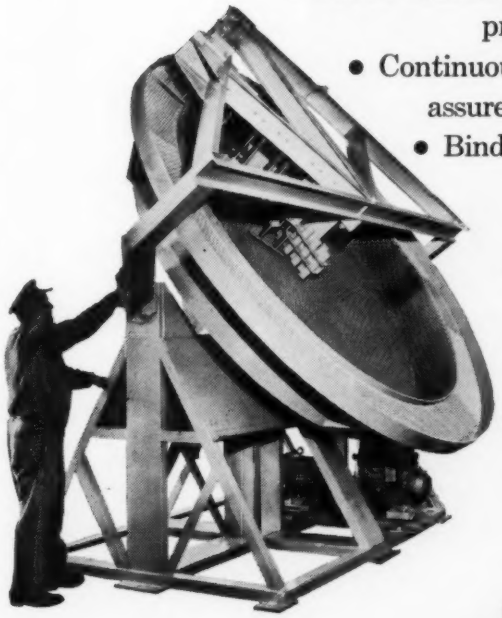
MULTIPOINT RECORDER

Δ Brown Instruments Division of Minneapolis-Honeywell Regulator Co. has introduced a multipoint strip chart recorder which, officials said, can be easily converted to change the number of points being measured, the actuation or the range.

The "Honeywell Universal Model 15 Electronik Recorder" is designed for application in laboratories and in industrial processes where frequent record changing is required or where it may be desirable to change the type of primary element or range of measurement.

Measurements can be switched from 2 to 3, 4, 6, 8, 10, 12, 16, 20 or 24 points by simply changing a shorting plug and appropriate indicating and prints wheels. Substitu-

DRAVO DISCS offer these plus values for pelletizing and mixing . . .



- Pellet uniformity is far superior to that produced by other methods.
- Continuous operation (not batch) assures higher production rates.
- Binder is unnecessary in many cases.
- Low overall cost per ton of output.
- Material in process can be viewed continuously.

Send for Bulletin Number 247. Write Dravo Corporation, Pittsburgh 25, Pennsylvania.

Manufactured under license agreement with Lurgi of Frankfort, Germany.

DRAVO CORPORATION

How to control dust from hot processes

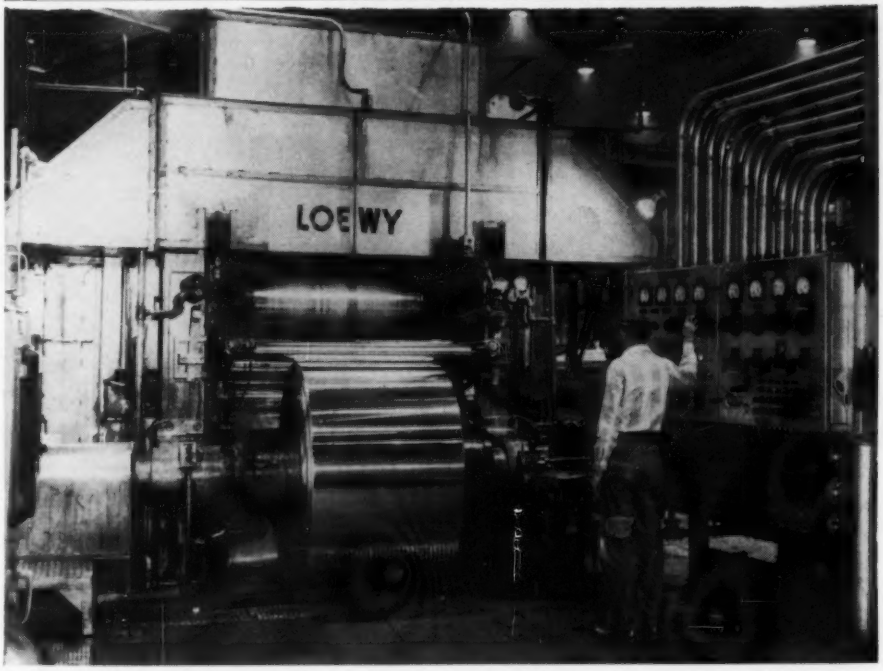
Tap the experience of American-Standard Industrial Division product specialists. They understand your air-pollution problems. And they're armed with a complete line of products for dust and fly-ash control—including the latest electrostatic precipitators. Every American-Standard collector offers long life and low maintenance. Each is engineered to take the brutal punishment of continuous operation at maximum capacity. When you want to control dust from the hot processes in your plant, be sure to give us a call. We have offices in all principal cities. American-Standard Industrial Division, Detroit 32, Michigan. In Canada: American-Standard Products (Canada) Limited, Toronto, Ontario.*

*American-Standard and Standard® are trademarks of American Radiator & Standard Sanitary Corporation

AMERICAN-Standard
INDUSTRIAL DIVISION

AMERICAN BLOWER PRODUCTS • ROSS PRODUCTS • KEWANEE PRODUCTS

AUTOMATIC GAGE CONTROL FOR ALUMINUM FOIL



An automatic gage control developed by the Westinghouse Electric Corp. is used to regulate accurately the thickness of aluminum foil being rolled on this four-high nonreversible cold-reduction foil mill operated by the Kaiser Aluminum and Chemical Corp. An x-ray gage measures the thickness of the foil as it is rolled and feeds a signal to the automatic gage control when the foil thickness deviates from the desired thickness setting. This control varies the speed of the rolls and thereby the coefficient of friction between the foil and the rolls as well as the strip tension to maintain uniform delivery thickness. This system can control the accuracy of 0.0007-in. double-foil aluminum (0.00035 in. each thickness) to within 1½ per cent.

tion of a new range card, terminal panel and scale, changes actuation and range.

Kits are available for point and for actuation and range change.

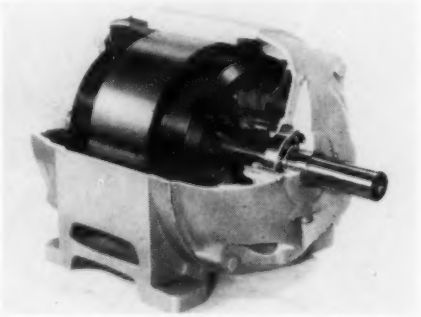
Universal models are equipped with measuring circuits for potentiometers or resistance thermometers mounted on interchangeable panels and zenor diode-regulated constant voltage units. Fixed cycle or synchro-balance printing models are available.

MOTOR INSULATION

Δ U. S. Electrical Motors Inc. has developed a special protection for windings functioning under adverse environmental conditions where conventional motor insulations have short life expectancy. The new protection is trade-marked under the name "Everseal," and is now available on all U. S. Motor types.

Molded in rigid high-grade resin, the encapsulated windings are fully protected against the attacks of excessive moisture, acids and gases (even in high concentrations); alkali or caustic conditions (lye, potash, ammonia, caustic soda); abrasives, carbon black, graphitic dusts and numerous other contaminants.

This stator is enclosed in a mold and liquid epoxy resin is injected under vacuum so that there are no air pockets to retain heat and decrease protection. Each winding is permanently and individually sealed.



Rigorous tests were made on prototypes of the present Everseal design. Encapsulated windings were exposed to radical temperature and humidity changes, being cycled from a hot and dry environment to a low temperature at 100 per cent humidity and receiving both short and prolonged voltage surges.

For accurate control of material flow — W-C CONSTANT-FEED WEIGH-HOPPER SYSTEMS

Wherever formulating or processing operations require highly accurate, uniform flow-rate control of dry, liquid or even hard-to-handle bulk materials, W-C Constant-Feed Weigh-Hopper Systems will do the job . . . continuously, automatically, economically.

Far more accurate than volumetric systems, W-C Constant-Feed Systems achieve precise control by continuously measuring the rate of material weight loss during discharge from a hopper (or tank), and regulating that discharge to maintain a linear rate of reduction.

Using pre-engineered, unitized components, W-C can provide a Constant-Feed System custom fitted to your particular applicational demands. The cost is reasonable because the components are standard . . . whether for Simplex, Duplex or Proportioning-Type Systems.

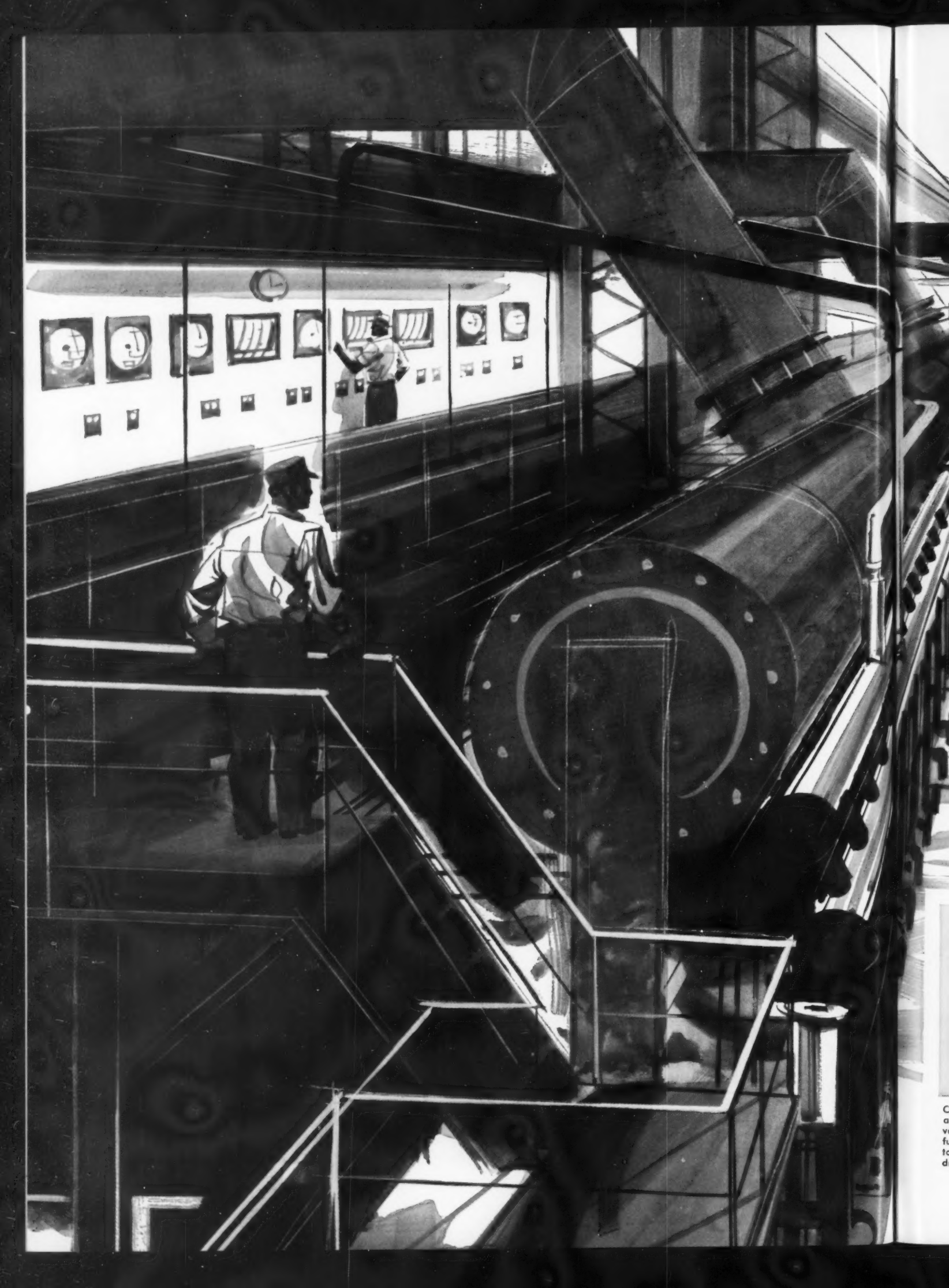
Typical applications include: Feeding pulverized coal to oxygen mixer for steel mill furnaces.

Write for new Bulletin 40

W-C

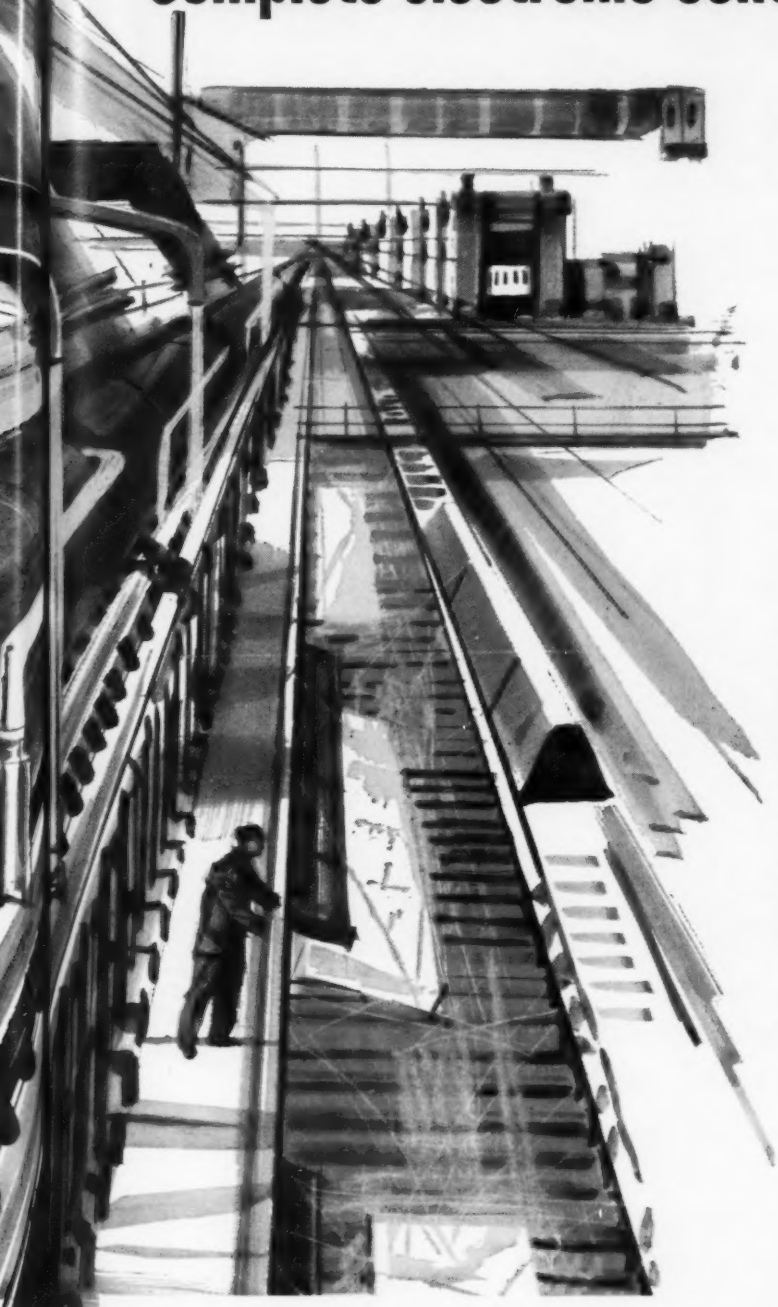
WEIGHING & CONTROL COMPONENTS, INC.
Div. of CompuDyne Corp.

E. County Line Road • Hatboro 16, Pa.
S.A. 2046



From Republic Flow Meters . . .

Complete electronic control for your reheat furnaces



When you install new reheat furnaces, or overhaul your existing ones, check the important advantages you get from Republic Flow Meters complete Control Engineering Service:

1. **Republic furnishes a complete line of instruments and electronic controllers. You get single-source service, single-source responsibility, from preliminary system design to start-up.**
2. **Republic's nation-wide network of experienced field engineers, valuable installation supervision, and final system adjustment and instruction of operating personnel assure you of a properly functioning system.**
3. **Republic's depth of experience in building pneumatic control systems and equipment for over forty years and electronic equipment for the last ten years, assures you the latest in system and product innovation.**

The complete line of Republic pneumatic and electronic equipment handles the recording, indicating and controlling functions for reheat furnace fuel flow and pressure, air flow and furnace pressure. Today, electronic controls for 250 ton furnaces (largest in the world) are being furnished by Republic.

Illustrated on these pages are a few of the many Republic products designed into your reheat furnace control system. Wherever accuracy of response and precise control are important, Republic products and experienced engineering service are available to meet your needs. For information contact the Republic representative nearest you, or write Republic Flow Meters Company, 2240 Diversey Parkway, Chicago 47, Ill. In Canada: Republic Flow Meters Canada, Ltd., Toronto. Subsidiary of Rockwell Manufacturing Company.

REPUBLIC INSTRUMENTS AND CONTROLS
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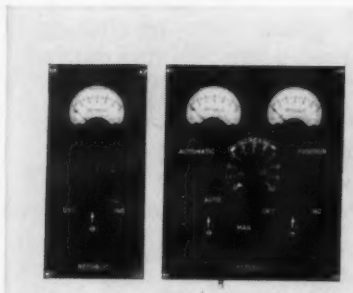
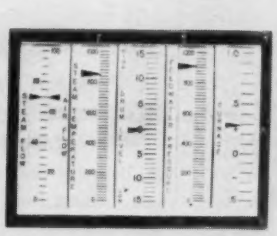
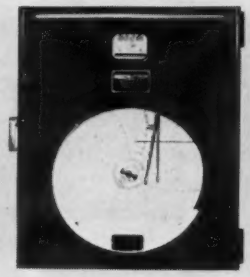


Complete electronic control systems are available for controlling the various functions in an open hearth furnace. Included are transmitters, totalizers, controllers and final drive units.

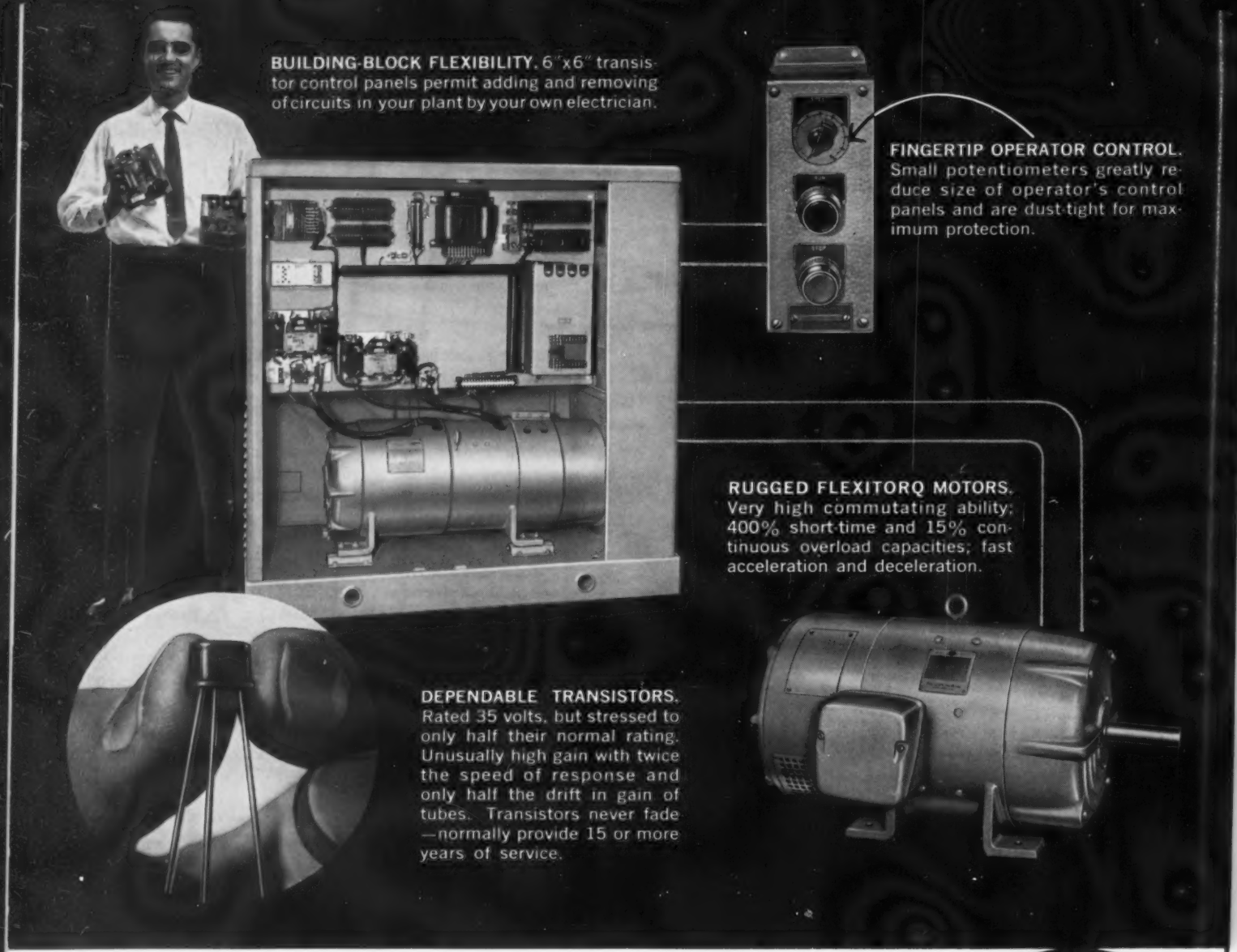


Republic V-5 Gauges for draft, pressure, flow temperature and differential pressures, have 5" vertical, easy-to-read scales. These small size gauges match performance of larger gauges, require quarter of the space.

Republic Final Drive Units operate valves, damper, inlet vanes, etc., in response to air loading pressures or electronic loading signals. They can be controlled automatically or manually, remotely or locally.



Republic Flow & Pressure Recorders register electrically, pneumatically or mechanically, are simple, compact units of sturdy construction.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New Side Trimming Line Installed In Tin Mill Will Improve Production Of Tinplate In Coils

Installation Called Most Modern Of Type In Industry

A new side trimming line to facilitate the production of tinplate in coils in Weirton Steel's Tin Mill Department was placed in operation recently.

W. H. Wright, Vice President and Chief Engineer, said the new installation, rated among the most modern pieces of equipment in the steel industry, was installed because of the increasing demand from customers for tinplate in coil form. The company will also continue to ship tinplate in the conventional cut sheets.

The new side trimming line, which began operating last month, and a second line, installed on an emergency basis, are used to trim the sides of the sheet steel before it is plated with tin, so it can be wound into coils and be ready for shipment as it comes off the tinning lines.

Mr. Wright explained that Weirton Steel's No. 4 and No. 5 tinplating lines have been equipped with edge control reels which insure that each coil is wrapped with a straight edge. This is necessary to prevent damage to the edges in bundling and shipping and also because straight edges are required when the coils are processed further by Weirton Steel customers.

Mr. Wright also reported the installation of a new bundling line, which began operating about three months before the new side trimmer. The bundling line utilizes machinery to wrap coils in heavy paper and fasten them with steel straps. Formerly, this was a hand operation.

The side trimming operation takes place after the steel has been tempered to customer specification by the skin mills and before it is plated with tin. This process eliminates the waste which formerly resulted when the side trimming was done on the cutting lines, after the tinplating process.

The No. 2 side trimming line has a maximum speed of 4,000 feet per minute while the No. 1 line operates at a speed of 1,200 feet per minute. The No. 2 line is able to handle 30-ton coils 85 inches in diameter and 45 inches wide. The line also is equipped with a mash welder, a relatively new operation which provides a smoother weld that does not damage other sections of the coil as it is wound.

All of the new facilities were designed by the Weirton Steel Engineering Department and installed by the company's Construction Department.

Reprinted from Employees Bulletin, Weirton Steel Company, February, 1960

Due to increasing demands from customers for tinplate in coil form, a new side trimming line was installed recently in the Tin Mill. The new trimming line, designed by Weirton Steel's Engineering Department and installed by the Construction D[illegible] the [illegible] of sheet steel bef[illegible] ted with ti[illegible]

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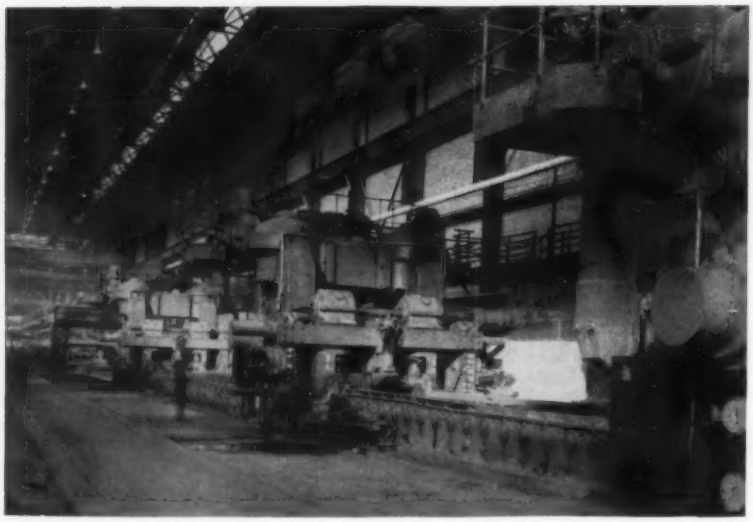

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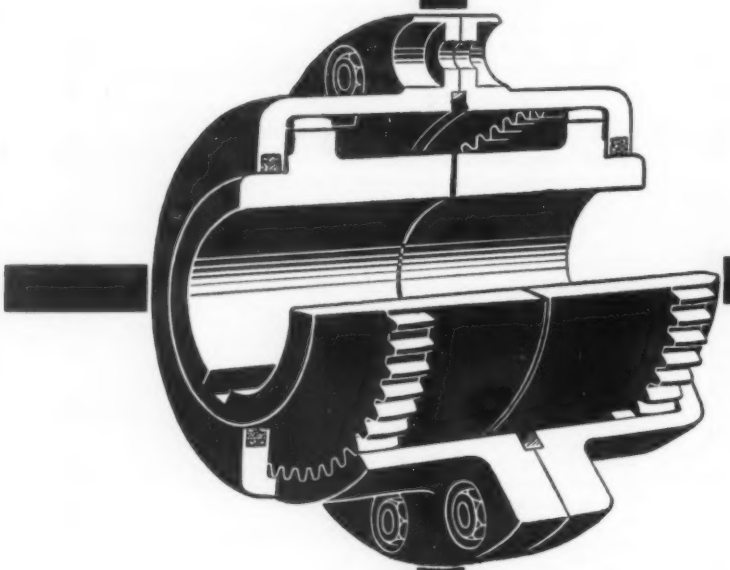

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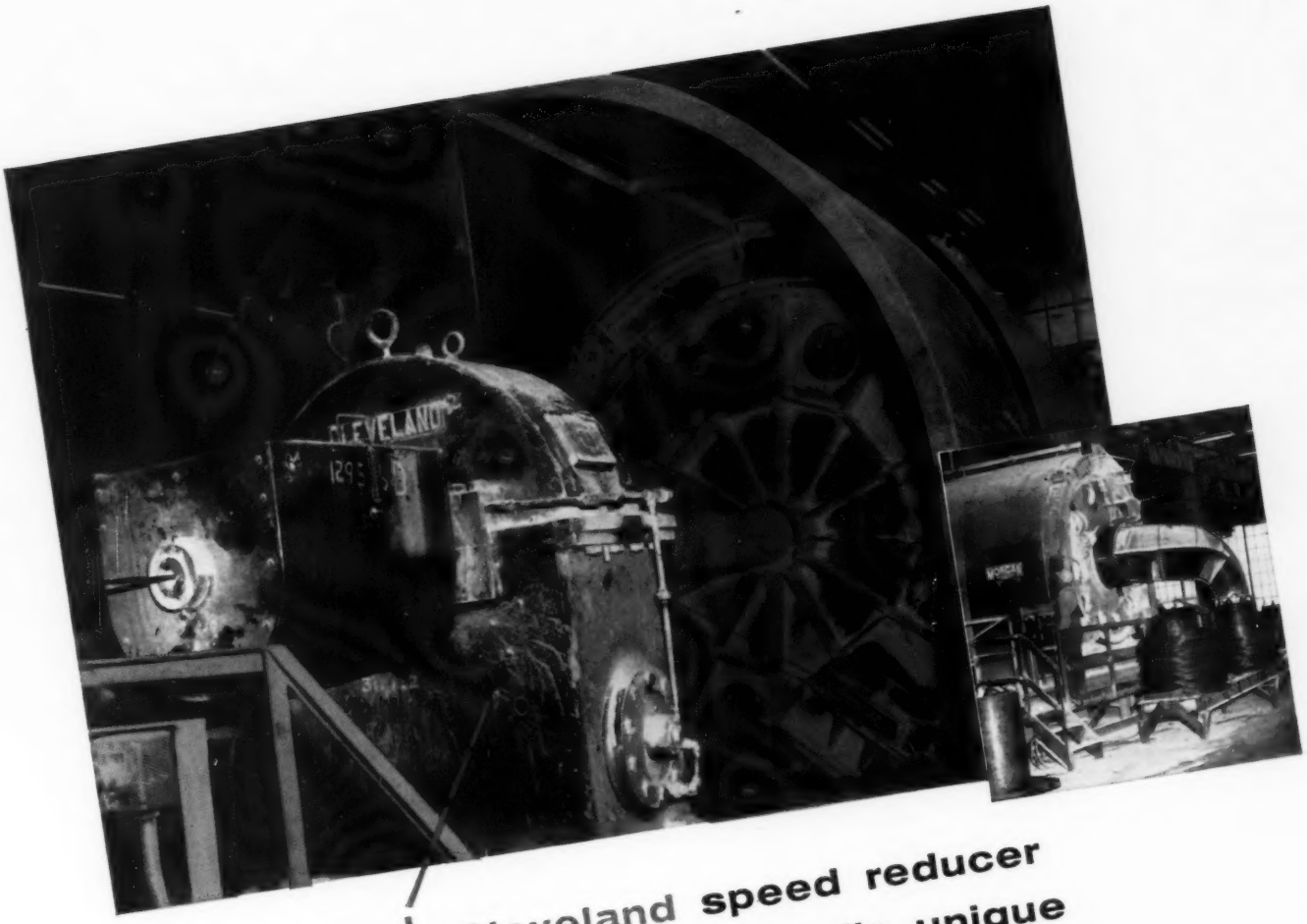

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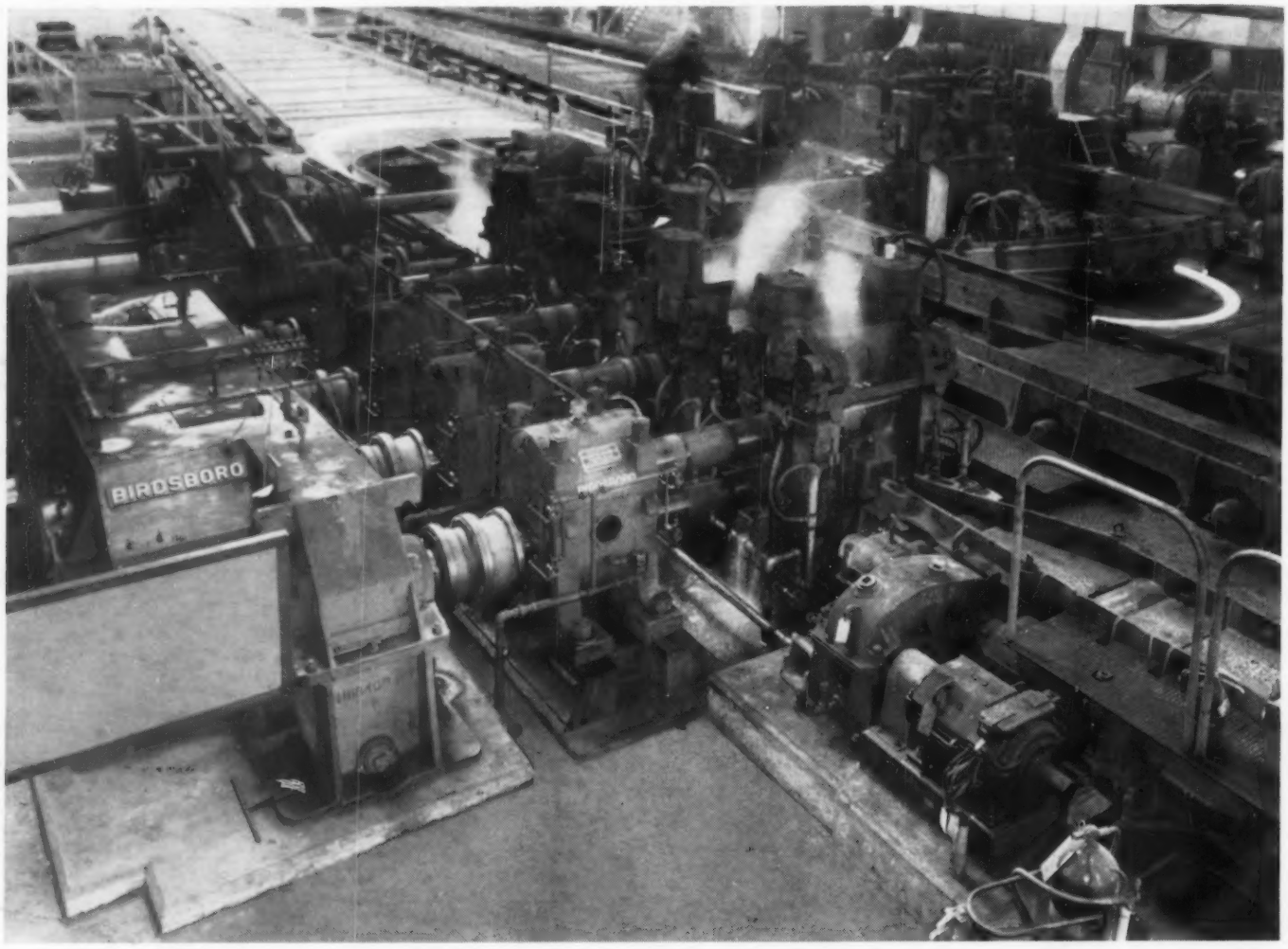

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